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USSR Report

MATERIALS SCIENCE AND METALLURGY



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CONTENTS

ANALYSIS AND TESTING

Study of Fe-Cr-P-C Alloys by Method of X-Ray Emission Spectroscopy
(K.M. Kolobova, I.N. Shabanova, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 2, Feb 86)..... 1

Phase Transitions in Cr29Ni18 Alloy Induced by Strain Under High Pressure
(D.I. Tupitsa, V.P. Pilyugin, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 2, Feb 86)..... 2

Transformation of Residual Austenite Under Load and Effect on Properties of Steel
(L.I. Kogan, V.K. Ogorodnik, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 2, Feb 86)..... 2

Shape Memory and Superelasticity of V_3Si and $Zr_xHf_{1-x}V_2$ Superconductors
(I.G. Zakrevskiy, V.V. Kokorin, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 2, Feb 86)..... 3

Short-Range Order in Cubic Titanium Nitrides
(I. Karimov, V.S. Presman, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... 4

Welded Joints of Zr+ 2.5% Nb Alloy and Dependence of Their Impact Strength on Structure of Seam Metal
(O.M. Barabash, A.B. Goncharov, et al.; AVTOMATICHESKAYA SVARKA, No 2, Feb 86)..... 5

| | |
|---|----|
| Fatigue Strength of Structural Cermet Materials (N.N. Sereda, A.K. Gerikhanov, et al.; PROBLEMY PROCHNOSTI, No 3, Mar 86)..... | 6 |
| Estimating Reliability of Pipes Under Cyclic Load in Thermal Power Apparatus (V.G. Verezemskiy; PROBLEMY PROCHNOSTI, No 3, Mar 86).... | 6 |
| Effect of Structural Instability and Oxidation on High-Temperature Fatigue Resistance of Heat-Resistant Alloy (Ye.Ya. Paliyenko, A.D. Pogrebnyak; PROBLEMY PROCHNOSTI, No 3, Mar 86)..... | 7 |
| Strength of Indium-to-Glass Adhesion and Method of Its Measurement (A.M. Magomedov; PROBLEMY PROCHNOSTI, No 3, Mar 86)..... | 8 |
| Ceramic Thermal Insulator in State of Plane Strain (O.A. Batanova, T.Ya. Yershova, et al.; PROBLEMY PROCHNOSTI, No 3, Mar 86)..... | 9 |
| Kinetics of Fracture in Glass-Crystal Composite System (V.N. Dubovik, A.M. Raykhel, et al.; PROBLEMY PROCHNOSTI, No 3, Mar 86)..... | 10 |
| Acoustic Emission During Deformation of High-Purity Aluminum Single Crystals (V.D. Natsik, Z.I. Bibik, et al., PROBLEMY PROCHNOSTI, No 3, Mar 86)..... | 10 |
| Cracking Resistance as Performance Criterion for Roller Steel (M.Ya. Belkin, V.Z. Kamalov, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 11 |
| Mechanical Properties and Fracture Characteristics of Steel After Repeated Thermomechanical Case Hardening (N.K. Kryuchkov; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 12 |

COATINGS

| | |
|--|----|
| Dependence of Spray Materials Consumption and of Coating Properties on Process Parameters of Gas-Flame Wire Metallization (Ye.N. Matveyshin, G.V. Kononov, et al.; SVAROCHNOYE PROIZVODSTVO, No 1, Jan 86)..... | 13 |
| Dependence of Properties of TiNi Intermetallic Compound Coatings on Parameters of Spray Deposition Process (N.V. Ragov, I.S. Geltman, et al.; SVAROCHNOYE PROIZVODSTVO, No 1, Jan 86)..... | 14 |

| | |
|--|----|
| Effect of Cold Working of Base Surface on Physicochemical Interaction of Materials During Gas-Flame Spray Coating (I.L. Kupriyanov, A.A. Verstak, et al.; SVAROCHNOYE PROIZVODSTVO, No 1, Jan 86)..... | 14 |
| Plasma-Sprayed TiC_xN_z -Base Cermet Coatings (M.Yu. Zashlyapin, B.V. Mitrofanov, et al.; SVAROCHNOYE PROIZVODSTVO, No 1, Jan 86)..... | 15 |
| Structure and Properties of Ni-Cr-Al-Plasma Coatings for Heat Resistant Nickel Alloys (B.N. Guzanov, N.V. Obabkov, et al.; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 16 |
| Diffusion Processes in Boundary Zone of Corrosion-Resistant Bimetals Produced by Cold Cladding (A.S. Mylnikov, A.A. Yershov, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 3, Mar 86)..... | 16 |
| Protection of Contact Pairs Against Self-Winding by Means of Diffusion Chrome-Plating (I.L. Kopylova, V.A. Kuznetsov, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 3, Mar 86)..... | 17 |

COMPOSITE MATERIALS

| | |
|--|----|
| Formation of Compounds of Calorized Boron Fibers With Aluminum Matrix in Rolling of Fiber Composite Material (B.A. Arsyev, S.O. Gevlich; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 19 |
| Effect of Interdiffusion of Components on Conductivity of Composite Materials With Unidirectionally Oriented Reinforcing Fibers and Barrier Coating (Yu.P. Zarichnyak, M.Yu. Malov; POROSHKOVAYA METALLURGIYA, No 3, Mar 86)..... | 20 |
| Thermal Expansion of Carbon-Aluminum Composite Material (I.M. Zhitkikh, A.A. Zabolotskiy, et al.; POROSHKOVAYA METALLURGIYA, No 3, Mar 86)..... | 20 |
| Superficial Segregation of Atoms in Ultrafine-Disperse Ag-Cu Alloy Powder (Yu.M. Shulga, A.S. Ivanov, et al.; POROSHKOVAYA METALLURGIYA, No 3, Mar 86)..... | 21 |

CORROSION

| | |
|---|----|
| Improving Anti-Corrosion Protection of Metal (IZVESTIYA, 24 Dec 85)..... | 23 |
|---|----|

| | |
|---|----|
| Corrosion Resistance of Welded Niobium-to-Steel Joints in Boiling HNO ₃ (G.D. Nikiforov, Ye.N. Sivov, et al.; SVAROCHNOYE PROIZVODSTVO, No 1, Jan 86)..... | 27 |
| Protective Properties of Composites (Steel Powder Aluminum Coatings) Obtained by Compacting Electrophoretic and Electrostatic Precipitates (V.N. Polyakov, V.P. Karshin, et al.; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 28 |
| FERROUS METALS | |
| New Horizontal Steel-Teeming Equipment (PRAVDA, 10 Feb 86)..... | 29 |
| Largest Blast Furnace Yields First Pig Iron (V. Minin; SOTSIALISTICHESKAYA INDUSTRIYA, 15 Apr 86).... | 30 |
| Tighter Schedule for Steel Output (P. Laptev; SOTSIALISTICHESKAYA INDUSTRIYA, 11 Apr 86)... | 33 |
| Compound Microalloying of Low-Pearlite Steels for Controlled Rolling (Yu.I. Matrosov; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 3, Mar 86)..... | 34 |
| Indicators of Fatigue Fracture in Metal Thread Made of U9 Steel (Yu.A. Koptev, V.V. Shestakov, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 3, Mar 86)..... | 35 |
| Dependence of Mechanical Properties of Cr12Mo Steel on Initial Structure, Heat Treatment, and Deformation Process (V.A. Yevstratov, V.I. Yeremin, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 35 |
| Impact-Fatigue Strength of Cast and Wrought High-Speed Tool Steels (V.Ye. Cherkasov, N.M. Yakshin, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 36 |
| Dependence of Properties of ONi6 Steel on Heat Treatment (B.P. Sharov, N.I. Karchevskaya, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 37 |
| Steels for Cryogenic Power Equipment (B.S. Yermakov, A.Ya. Nikolaich, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 37 |

| | |
|---|----|
| Solubility of TiC and Nb ₄ C ₃ in High-Chromium Ferrite (N.A. Gorokhova, V.I. Sarrak, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 38 |
| Magnetic Transformation in Cr ₁₅ Mn ₁₆ Ni ₂ Al ₂ Chromium-Manganese Steel (O.A. Bannykh, P.Ye. Merinov, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 39 |
| NONFERROUS METALS AND ALLOYS: BRAZES AND SOLDERS | |
| New Nonferrous Metal Process Developed (N. Lazareva; MOSKOVSKAYA PRAVDA, 30 Mar 86)..... | 40 |
| Phase Stresses in Embrittlement of Ingots of Highly Alloyed Molybdenum (S.I. Yudkovskiy, V.K. Ivanov, et al.; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 46 |
| Effect of Sc, La, Sm on Oxidation of Aluminum (V.G. Shevchenko, V.I. Konopenko, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 43 |
| Comminution and Sieve Analysis of Ti-Sponge Powder (I.A. Shulyak, A.P. Archakov, et al.; TSVETNYYE METALLY, No 3, Mar 86)..... | 44 |
| Quality of Hard Alloys for Rock and Well Drilling Tool (N.P. Krayev; TSVETNYYE METALLY, No 3, Mar 86)..... | 44 |
| NONMETALLIC MATERIALS | |
| Diamond-Hard Material Created (V. Vladimirov; SOTSIALISTICHESKAYA INDUSTRIYA, 3 Apr 86)..... | 46 |
| Energy Characteristics of Cutting Laminate Plastics With Continuous-Wave CO ₂ -Laser Beam (A.G. Grigoryants, A.A. Sokolov; SVAROCHIJOYE PROIZVODSTVO, No 1, Jan 86)..... | 47 |
| Further Research on the Synthesis of Aluminum Titanate (V.P. Tarasovskiy, Ye.S. Lukin, et al.; OGNEUPORY, No 1, Jan 86)..... | 47 |
| A Study of the Slip-Casting of Ceramics Based on Chemically Co-Precipitated Stabilized ZrO ₂ (Yu.Ye. Pivinskiy, A.A. Dabizha, et al.; OGNEUPORY, No 1, Jan 86)..... | 48 |

| | |
|--|----|
| Investigating the "Aging" Process of Quartz Ceramics (Ye.I. Syzdaltsev; OGNEUPORY, No 1, Jan 86)..... | 49 |
| Using Standard-Referenced Contact Porometry To Study the Pore Structure of Reaction-Sintered Silicon Nitride (I.Ya. Guzman, Ye.B. Bendovskiy, et al.; OGNEUPORY, No 1, Jan 86)..... | 50 |
| Possibility of Deep Doping of Semiconductor Plates by Remelting the Surface Layer With a Concentrated Light Beam With Simultaneous Body Heating (D.M. Dureyev, A.I. Lendyayev; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 50 |
| Crystallization of Droplets Transferred From a Target Heated by Laser Radiation on a Single Crystal Substrate (P.D. Kervalishvili, E.R. Kuteliya, et al.; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 51 |
| Magnetoresistance of Cu-Mn and Cu-Mn-Ni Spin Glasses in Strong Magnetic Fields (V.M. Beylin, L.A. Serebrenik, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 2, Feb 86)..... | 51 |
| Thermomagnetic Treatment of Amorphous Gd-Co Films (G.S. Kandaurova, V.V. Lesnykh, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 2, Feb 86)..... | 52 |
| Effect of Gadolinium Dopant on Electrical and Optical Properties of Shaped Silicon Crystals (N.V. Abrosimov, V.N. Abrosimova, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 53 |
| Etching Edge-Effect and Its Use in Fabrication of Microlenses (L.N. Vozmilova, T.G. Malyarova; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 54 |
| Polycrystalline ZnSe (I.N. Vladyko, V.I. Dernovskiy, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 55 |
| Interaction of HgTe and Pb (V.N. Tomashik, P.F. Vengel, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 56 |
| Properties of PbTe-MnTe ₂ Alloys (P.G. Rustamov, Ch.I. Abilov, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 57 |

| | |
|--|----|
| Defects in Synthetic Quartz Single Crystals (M.N. Danchevskaya, O.G. Ovchinnikova, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 58 |
| New $\text{Bi}_2\text{AB}_2\text{O}_9$ Bismuth Compounds (L.A. Shebanov, L.V. Korzunova, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 59 |
| Dependence of Temperature Stability of Resonance Frequency of Ferroelectric Piezoceramic Materials With Perovskitic Structure on Individual Characteristics of Their Constituent Cations (L.D. Grineva, S.V. Gavrilyachenko, et al.; NEORGANICHESKIYE MATERIALY, No 2, Feb 86)..... | 60 |
| Growing H_2O Single Crystals by Floating-Zone Method Under Conditions Simulating Weightlessness (Sh. Mavlonov; NEORGANICHESKIYE MATERIALY, No 2, Feb 86). . | 61 |
| Welding of Plastic Tubes Under Pressure Generated by Magnetic Pulse Field (V.A. Shishkin, N.P. Konovalov, et al.; AVTOMATICHESKAYA SVARKA, No 2, Feb 86)..... | 62 |
| Effect of Radiation on Radiative and Non-Radiative Recombination in Heterosystems Based on GaAs and $\text{Al}_x\text{Ga}_{1-x}\text{As}$ (O.Yu. Borkovskaya, N.L. Dmitruk, et al.; FIZIKA I TEKHNIKA POLYPROVODNIKOV, No 2, Feb 86)..... | 63 |
| Near-Surface Band Bending in GaAs With Negative Electron Affinity (A.D. Korinfskiy, A.L. Musatov; FIZIKA I TEKHNIKA POLUPROVODNIKOV, No 2, Feb 86)..... | 63 |
| Intracenter Electroluminescence of Vanadium in GaAs (V.S. Vavilov, V.A. Morozova; FIZIKA I TEKHNIKA POLUPROVODNIKOV, No 2, Feb 86)..... | 64 |
| Effect of Gaseous Phase on Structural Formation of Silicon Carbide Materials (T.P. Markholiya, I.I. Kozelkova, et al.; OGNEUPORY, No 3, Mar 86)..... | 65 |
| Study of Effect of Granular Composition of Synthetic Corundum on Product Properties (N.M. Permikina, Ye.Ya. Gimpelman, et al.; OGNEUPORY, No 3, Mar 86)..... | 66 |

| | |
|---|----|
| Preparing Light-Weight Heat-Insulated Refractory Products With Operating Temperatures Up to 1750°C (Ya.Z. Shapiro, O.V. Zhuchenko, et al.; OCNEUPORY, No 3, Mar 86)..... | 66 |
| PREPARATION | |
| Structural Conversions Upon Explosive and Heat Treatment of Steel (E.A. Savchenkov, V.K. Shashkova, et al.; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 68 |
| Study of Influence of Titanium and Zirconium on Rate of Saturation of Porous Tungsten With Copper and Change in Resistivity of the Alloy During Annealing (A.E. Ligachev, I.N. Pashkov, et al.; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 69 |
| Elastic and Kinetic Properties of Aging Fe-Mn-Al-C Steel (V.S. Litvinov, V.D. Kibalnik, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 2, Feb 86)..... | 69 |
| Using Chips of Titanium Alloys for Production of TC-Type Hard Alloys (S.S. Kiparisov, Yu.V. Levinskiy, et al.; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 70 |
| Electrode Materials Based on Refractory Borides for Alloying by Electric-Spark Process (A.D. Verkhuturov, I.A. Podchernyayeva, et al.; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 71 |
| Production of Materials by Electric-Discharge Sintering of Pulverized Bronze Chips (A.I. Raychenko, A.S. Morozov, et al.; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 72 |
| Mechanical Properties of Titanium Impregnated With Bismuth Alloy (V.G. Yenevich, V.A. Pisarenko, et al.; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 73 |
| Dependence of Mechanical Properties on Composition of Si_3N_4 - Base Material (G.A. Gogotsi, Ya.L. Grushevskiy, et al.; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 73 |
| High-Strength Ti + 5% Al + 2.5% Fe Alloy and Its Use as Material for Surgical Implants (U. Zwicker; TSVETNYYE METALLY, No 3, Mar 86)..... | 74 |

| | |
|--|----|
| Corrosion Resistance of Fine-Disperse Iron and Fe-Co-Ni Alloy Powders (Z.M. Melnichenko, G.K. Rashevskaya, et al.; POROSHKOVAYA METALLURGIYA, No 3, Mar 86)..... | 75 |
| Forms of Oxygen Bond in Fine-Disperse Molybdenum Powder and Features of Complete-Reduction Annealing (R.U. Kalamazov, A.T. Ibragimov; POROSHKOVAYA METALLURGIYA, No 3, Mar 86)..... | 76 |
| Structurization of Al-Cu Alloy During Sintering (A.P. Savitskiy, G.N. Romanov; POROSHKOVAYA METALLURGIYA, No 3, Mar 86)..... | 77 |
| Selection of Raw Powders for Production of Sintered Permalloys (Ye.M. Minayev; POROSHKOVAYA METALLURGIYA, No 3, Mar 86)..... | 78 |
| Kinetics of Austenite-to-Bainite Transformation and Internal Stresses in Ball-Bearing Steel During Quenching (A.N. Kulakov, A.S. Kagan, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 4, Apr 86)..... | 78 |
| TREATMENTS | |
| Increased Use of Laser Technology in Metallurgy (A. Presnyakov; PRAVDA, 12 Feb 86)..... | 80 |
| Plasma-Arc Heat Treatment of the Surface of Iron-Carbon Alloys (N.V. Livitan, S.P. Polyakov, et al.; FIZIKA I KHIMIYA OBRABOTKI METALLOV, No 1, Jan-Feb 86)..... | 82 |
| Local Alloying of Sintered Hard-Alloy Articles (A.F. Lisovskiy, N.V. Tkachenko, et al.; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 83 |
| Development of Grain Orientation in Powder Magnets in Alternating and Constant Magnetic Fields (G.I. Yaglo, A.S. Kotenev; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 84 |
| Effect of Heat Treatment on Structure and Magnetic Properties of Ce(Co,Cu,Fe)₆ Alloys (A.A. Pavlyukov, O.S. Opanasenko, et al.; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 85 |
| Use of NbC Heaters for Growing SiC Single Crystals (V.S. Kindysheva, L.F. Maltseva, et al.; POROSHKOVAYA METALLURGIYA, No 2, Feb 86)..... | 86 |

| | |
|---|----|
| Effectiveness of Various Heat Treatments for Hardening Deformed Low-Carbon Steel (G.N. Teplukhin; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 3, Mar 86)..... | 86 |
| Effect of Preliminary Heat Treatment on Properties of Nitrided Structural Steels and Tool Steel (V.V. Simochkin; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 3, Mar 86)..... | 87 |
| Grain Orientation and Properties of Cold-Rolled Powder-Metal Strips of High-Silicon and High-Aluminum Iron Alloys in Disorder--Order Range (V.M. Beglov, A.M. Glezer, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 3, Mar 86)..... | 88 |
| WELDING, BRAZING AND SOLDERING | |
| Friction Spot Welding of Copper Alloys and Aluminum Alloys (L.A. Polinovskiy, Ye.S. Yanshin; SVAROCHNOYE PROIZVODSTVO, No 1, Jan 86)..... | 89 |
| Fracture of Welded Joints of Corrosion-Resistant Steel in Contact With Copper (V.Ye. Lazko, O.K. Revyakina, et al.; SVAROCHNOYE PROIZVODSTVO, No 1, Jan 86)..... | 90 |
| Effect of Hydrogen on Cracking Resistance of Platinum Alloy (O.D. Smiyan, B.I. Shnayder, et al.; AVTOMATICHESKAYA SVARKA, No 2, Feb 86)..... | 90 |
| Dependence of Pore Formation in Seam During Electron-Beam Welding of Copper on Pretreatment of Edges (O.K. Nazarenko, V.Ya. Agarkov, et al.; AVTOMATICHESKAYA SVARKA, No 2, Feb 86)..... | 91 |
| Low-Cycle Fatigue of Welded Joints of 1201 Aluminum Alloy (V.I. Ryazantsev, Y.I. Tolkachev, et al.; AVTOMATICHESKAYA SVARKA, No 2, Feb 86)..... | 92 |
| Heat Treatment of Cutting Tool Hard-Faced With 110Mo6Cr3V2Ti Powder Wire (B.N. Gorpenyuk, V.A. Stepanenko, et al.; AVTOMATICHESKAYA SVARKA, No 2, Feb 86)..... | 93 |
| Characteristics of Transition Zone in Aluminum-Steel Joints Produced by Contact Butt Welding (M.A. Lukin, S.I. Kuchuk-Yatsenko, et al.; AVTOMATICHESKAYA SVARKA, No 2, Feb 86)..... | 94 |

EXTRACTIVE METALLURGY AND MINING

| | |
|--|-----|
| Economic Development of BAM Area (N. Singur; EKONOMICHESKAYA GAZETA, No 3 Jan 86)..... | 96 |
| Shemonaikha Complex Ore Deposit Now Operational (V. Burenko; SOTSIALISTICHESKAYA INDUSTRIYA, 30 Jan 86)..... | 99 |
| Lead Concentrate Unit Delayed (V. Vakhayev; PRAVDA VOSTOKA, 11 Apr 86)..... | 100 |
| Distribution of Au and As Among Products of Smelting of Robust Au-As Concentrates (V.N. Mashuryan, A.G. Borisova, et al.; TSVETNYYE METALLY, No 3, Mar 86)..... | 102 |
| Efficiency of Extraction of Fine Gold by Gravity Process Equipment (T.B. Belova, S.I. Khrushchenko; TSVETNYYE METALLY, No 3, Mar 86)..... | 103 |
| Use of Reagent IM-50 in Flotation of Cu-Ni Ore (L.D. Artemyeva, R.I. Sulina, et al.; TSVETNYYE METALLY, No 3, Mar 86)..... | 103 |

/9835

ANALYSIS AND TESTING

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STUDY OF Fe-Cr-P-C ALLOYS BY METHOD OF X-RAY EMISSION SPECTROSCOPY

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 61, No 2, Feb 86 (manuscript received 22 Mar 85) pp 278-283

[Article by K.M. Kolobova, I.N. Shabanova and V.R. Galakhov, Metal Physics Institute, Ural Science Center, USSR Academy of Sciences]

[Abstract] An experimental study of corrosion-resistant amorphous Fe-Cr-P-C alloys was made by the method of x-ray emission spectroscopy, for the purpose of determining the distribution of electron states over a wide energy range. Ribbon specimens containing 0.3 or 10 atom.% Cr, 13 or 18 atom.% P, 3.5 or 7 atom.% C in various combinations were produced by quenching from the liquid state, from temperatures 150°C or 550°C above the melting point, with a jet of the melt being fed onto a rotating copper disk. A crystalline specimen of the $FeCr_{10}P_{13}C_7$ alloy, for comparison, was produced by heating the melt to 1120 K and holding it at that temperature for 4.5 h. Upon excitation of the iron with mixed x-radiation from a copper anode, fluorescent emission in its K-band was recorded in IV-order reflection by a prismatic quartz crystal, with $CrK_{1,1}$ and $CoK_{1,1}$ lines serving as

references. A comparative analysis of the crystalline alloy and its amorphous counterpart has revealed that both contain crystalline iron with not only iron atoms but also phosphorus and carbon atoms in the nearest surroundings, in ratios characteristic of $Fe_3P_{1-x}C_x$ carbophosphides with a Fe-P-C bond. In the spectrum of the amorphous alloys, however, the emission peak is shifted toward longer waves. The long-wave E-anomaly, associated with 2s-states of carbon, is more distinct and its shift toward higher energy as well as the somewhat higher emission intensity within this region indicate a stronger Fe-C interaction. The spectra of all amorphous alloys have a second long-wave anomaly, within the 12-13 eV range, probably attributable to a preferential grouping of phosphorus atoms and to splitting of the P3s band. The lower emission intensity of the FeK_3 side and the higher emission intensity within the F-peak region indicate that Fe-Fe interaction is weaker in an amorphous alloy than in a crystalline one. The authors thank V.Yu. Vasilyev and V.B. Chernogorenko for supplying amorphous alloys and iron phosphides and E.Z. Kurmayev for helpful comments on the manuscript. References 9: 8 Russian, 1 Western.

2415/9835
CSO: 1842/167

UDC 669.24'26:669.017.3:539.89

PHASE TRANSITIONS IN Cr29Ni18 ALLOY INDUCED BY STRAIN UNDER HIGH PRESSURE

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 61, No 2, Feb 86 (manuscript received 8 Dec 84 in final version 15 Apr 85) pp 325-330

[Article by D.I. Tupitsa, V.P. Pilyugin, R.I. Kuznetsova, G.G. Taluts and V.A. Teplov, Metal Physics Institute, Ural Science Center, USSR Academy of Sciences]

[Abstract] An experimental study of the Cr29Ni18 alloy, characterized by a low energy of lattice packing defects, was made for the purpose of exploring its phase transitions induced by plastic deformation under high pressure. Specimens of this alloy as well as specimens of its Cr29Ni18%o2 modification, disks 5 mm in diameter and up to 0.3 mm thick, were quenched in water from 1300°C. Such a specimen was placed horizontally between two conical anvils (small bases also 5 mm in diameter) made of VK6 alloy and compressed. With the pressure constant, at various levels covering the 2-10 GPa range, the anvils were rotated through some angle relative to each other about their common vertical axis so as to shear the compressed disk. The specimens thus plastically deformed, without slippage under pressure higher than 1.5 GPa and with correspondingly large friction, were examined under a transmission electron microscope as well as by the methods of x-ray diffraction with a CrK_α-radiation source and nuclear magnetic resonance. The results of structural and phase analysis by these methods, plotted in the strain-pressure plane, b.c.c.-f.c.c.-c.p.h. transition, and a range of b.c.c.->f.c.c. transition only. References 13: 8 Russian, 5 Western.

2415/9835
CSO: 1842/167

UDC 669.15'78'293-194:539.4.015

TRANSFORMATION OF RESIDUAL AUSTENITE UNDER LOAD AND EFFECT ON PROPERTIES OF STEEL

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 61, No 2, Feb 86 (manuscript received 18 Jun 85) pp 409-412

[Article by L.I. Kogan, V.K. Ogorodnik, N.N. Pankova and R.I. Entin, Institute of Metal Science and Metal Physics, Central Scientific Research Institute of Ferrous Metallurgy imeni I.P. Bardin]

[Abstract] Since residual austenite in quenched and low-temperature tempered steel increases its ductility and plasticity, residual austenite and its transformation in the 08G4B alloy steel (0.08% C, 4.18% Mn, 0.05% Nb, $Ac_1 = 610^\circ\text{C}$ and $Ac_3 = 835^\circ\text{C}$) under a load equivalent to mechanical testing

was quantitatively determined after three different heat treatments: 1) quenching in water after austenitization at 900°C for 1 h; 2) water cooling after tempering at 580°C for 1 h; 3) air cooling after austenitization at 660-680°C for 1 h. The results of this determination, made with the aid of x-ray structural analysis and nuclear gamma resonance, indicate retention of almost all the austenite formed during quenching. This is attributable to an appreciable increase of the carbon content, up to 0.55% C, during austenitization. Islets of this austenite were found, under an electron microscope, to have settled along the boundaries of packs of martensite needles. None of it was transformed as a result of cooling from room to liquid-nitrogen temperature. Under load during tension and impact tests, however, all the residual austenite at the fracture sites had been transformed into martensite and only all of the residual austenite far from these sites had been retained. Transformation of residual austenite by deformation under load improves the impact strength of steel (08G4B) more than does transformation of residual austenite by cooling to -196°C, as in the case of 30KhN3 alloy steel. References 10: 6 Russian, 4 Western.

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UDC 669.17

SHAPE MEMORY AND SUPERELASTICITY OF V₃Si AND Zr_xHf_{1-x}V₂ SUPERCONDUCTORS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 61, No 2, Feb 86 (manuscript received 21 May 85) pp 412-415

[Article by I.G. Zakrevskiy, V.V. Kokorin and A.D. Shevchenko, Metal Physics Institute, UkrSSR Academy of Sciences]

[Abstract] The shape memory effect in V₃Si single crystals and in Zr_xHf_{1-x}V₂ (Zr_{0.5}Hf_{0.5}V₂, 87%ZrV₂, 70%HfV₂) polycrystals and the superelasticity

effect in these superconducting materials were measured over the 4.2-300 K temperature range. Specimens of Zr_xHf_{1-x}V₂ polycrystals were produced by the technology which had been developed at the Metal Physics Institute (UkrSSR Academy of Sciences) according to the Jurisch-Berthel-Ullrich method. Two groups of V₃Si specimens were grown by the floating-zone method at the GDR Academy of Sciences in Dresden, with the temperature dependence of their electrical resistivity characterized by the ratio $\alpha = R_{300K}/R_{17.5K}$ equal to 46 ("pure" single crystals) and 14 ("dirty" single crystals) respectively. The "dirty" ones were grown under a vacuum of 10⁻⁵ torr and the "pure" ones were grown in a protective atmosphere of 70 kPa Ar+10 kPa H₂. The deflection under a transverse load was measured by the induction method and recorded with a PDP 4-002 XY-plotter. The temperature was measured with a Cu/Cu+0.2%Fe thermocouple, accurately within 1 K over the entire range. The deflection of all specimens within the premartensite temperature range has been found to increase with lowering of the temperature, probably because

the modulus of elasticity decreases as the martensite transformation temperature is approached. The data reveal a shape memory of "pure" V₃Si single crystals with the Laves phase, owing to martensite structural transformation, and superelasticity of "dirty" V₃Si single crystals with the Laves phase, owing to martensite structural transformation, and superelasticity of "dirty" V₃Si single crystals with the low-temperature phase forming under load but vanishing upon load removal. The authors thank Dr M. Jurisch for supplying the V₃Si single crystals and I.K. Zasimchuk and Ye.L. Zhevolut for assisting in the orientation of the "pure" V₃Si single crystals. References 7: 5 Russian, 2 Western.

2415/9835
CSO: 1842/167

UDC 539.27+546.3

SHORT-RANGE ORDER IN CUBIC TITANIUM NITRIDES

moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 16 May 84) pp 234-236

[Article by I. Karimov, V.S. Presman and D.Ya. Khvatinskaya, Institute Physics Institute, UzSSR Academy of Sciences]

[Abstract] A study of the short-range order in titanium nitrides was made, for the purpose of determining its relation to the structure of ordered phases and to changes in the arrangement of interstitial atoms within the region of the constitution diagram where the long-range order changes. Polycrystalline specimens of three nitrides (TiN_{0.55}, TiN_{0.67}, TiN_{0.75}) were annealed at 1100-1200°C and quenched to room temperature, the disordered γ -phase being the equilibrium phase in all three nitrides within that range of annealing temperatures. Quenching did not break up the γ -phase in the TiN_{0.55} specimen and no phase transformations occurred in the other two specimens down to room temperature. The short-range order was examined on neutron diffractograms of the specimens taken in a DN-500 (GDR) diffractometer with a neutron beam of 0.1073 nm wavelength. These revealed a diffuse scattering pattern from which the order parameters could be determined. Two intensity peaks were recorded in the scattering patterns of all three specimens, one within the 10-18° angle and one within the 20-41° angle. The short-range order in TiN_{0.55} differs from that in TiN_{0.67} and in TiN_{0.75}, however, which is attributable to existence of a single phase in the N/Ti_{0.67} region above 400°C without a split into the two γ -Ti₂N and β -TiN phases during quenching. References 8: 3 Russian, 5 Western (2 in Russian translation).

2415/9835
CSO: 1842/174

WELDED JOINTS OF Zr+ 2.5% Nb ALLOY AND DEPENDENCE OF THEIR IMPACT STRENGTH
ON STRUCTURE OF SEAM METAL

Kiev AVTOMATICHESKAYA SVARKA in Russian No 2, Feb 86
(manuscript received 4 Jan 85, in final version 13 Mar 85) pp 42-45

[Article by O.M. Barabash, candidate of physico-mathematical sciences, A.B. Goncharov, candidate of technical sciences, N.P. Kushnareva, candidate of physico-mathematical sciences, M.M. Nerodenko, doctor of technical sciences, and A.I. Ustinov, candidate of physico-mathematical sciences, Kiev]

[Abstract] Welded joints of the Zr+ 2.5% Nb alloy containing 0.56% [O], 0.0067% [N], 0.006% [i] were tested for impact strength over the 203-420 K temperature range and its dependence on both the structure and phase composition of the seam metal. Specimens of this alloy, 2 mm thick and 300x60 mm² large, were welded inside a chamber in a high-purity helium atmosphere with a nonconsumable tungsten electrode. Electric welding was done at five different rates with correspondingly different currents: 1) 0.28 cm/s with 65 A (16 V); 2) 0.56 cm/s with 80 A (16 V); 3) 1.12 cm/s with 120 A (18 V); 4) 1.68 cm/s with 180 A (18 V); 5) 2.24 cm/s with 240 A (18 V). The joints were heat treated by annealing under vacuum ($0.13 \cdot 10^{-3}$ Pa) at 850 K for 2-4-6-10 h. The phase composition of weld seams was determined on the basis of x-ray diffraction analysis and photographs taken in an x-ray tube with iron anode in monochromatized light, using a BS-540 transillumination microscope. The structural stability of joints was estimated from the temperature rise due to an increase of internal friction as background effect, the latter being measured by the method of torsional low-frequency (2-6 Hz) vibrations over the 293-1273 K temperature range under a residual pressure not exceeding $1.3 \cdot 10^{-3}$ Pa. The impact strength of all joints was subsequently found to be within 68-70 J/cm², the impact strength of the base metal being 160-170 J/cm². Annealing for 2-10 h had not increased the impact strength of joints produced at rates of 0.28-0.56 cm/s. Annealing for 2 h was found to increase the impact strength of joints produced at rates of 1.12-1.63 cm/s to 112-135 J/cm², but annealing them for 4-10 h was found to reduce their impact strength back to the original level. A correlation of stress and strain data characterizing strength and plasticity of the welded joints at test temperatures with phase transformations which have occurred during welding and during subsequent annealing indicates that the increase of impact strength in the case of joints produced at rates of 1.12-1.68 cm/s and then annealed at 850 K for 2 h is attributable to formation of twinned martensite and hardening of the twin-grain boundaries by precipitation of the fine-disperse Nb-base -phase in the seam metal. References 5 (Russian).

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FATIGUE STRENGTH OF STRUCTURAL CERMET MATERIALS

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 86
(manuscript received 2 Jan 85) pp 7-9

[Article by N.N. Sereda, A.K. Gerikhanov, M.S. Kovalchenko, V.A. Tsyban and L.G. Pedanov, Institute of Materials Science Problems, UkrSSR Academy of Sciences, Kiev]

[Abstract] A study of four cermet materials was made, three of them based on titanium carbide (KTS-1N, KTS-1, KTNKh-70) and one based on tungsten carbide (VK-15), for a determination of their fatigue strength under a nonuniform tension-compression load alternating at a frequency near 12 kHz. Bar specimens 60 mm long and $2.5 \times 5.0 \text{ mm}^2$ in cross-section were mounted horizontally in a clamp at one end, with the other end free, and excited into second-mode transverse vibrations. The test equipment consisted of a master oscillator energizing a magnetostrictive exciter with a concentrator-tip under the clamp through a power amplifier, also a frequency meter, a cycle counter, and a microscope for microstructural and fractographic examination. The experimental data have been processed and evaluated in correlation with the applicable theoretical formula for stress, disregarding the forces of rotational inertia and the effect of transverse forces on the beam reflection. The results indicate that the TiC cermets have a fatigue strength of 190-200 MPa on a $5 \cdot 10^8$ cycles base, differences in fatigue strength being attributable to different modifying additives in the materials, while the fatigue strength of the WC cermet is 300 MPa on a $5 \cdot 10^8$ cycles base. The fatigue strength depends largely on the phase composition of the material, the material with the most homogeneous and uniform distribution of carbide grains having the best characteristics. The mode of fracture was found to change from brittle under a static load to ductile under a cyclic load. References 5: 4 Russian, 1 Western.

2415/9835
CSO: 1842/193

ESTIMATING RELIABILITY OF PIPES UNDER CYCLIC LOAD IN THERMAL POWER APPARATUS

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 86
(manuscript received 27 Feb 84) pp 10-14

[Article by V.G. Verezemskiy, Moscow]

[Abstract] Reliability estimates are made for metal pipes with welded joints under cyclic loads in thermal power apparatus on the basis of maximum

referred stresses and an either complete or truncated log normal distribution of the number of cycles required for fracture. The analysis is applied to regular cyclic mechanical and thermal loads but random strength characteristics of the seam metal in pipe joints, assuming that all joints have been inspected for defects and found to be free of unlikely rare large defects. The analysis covers the condition of two simultaneous cyclic actions with different amplitudes and different degrees of asymmetry. It is then extended to the more general condition of any number of such simultaneous different cyclic actions, in which cases the multiplication rule applies to the probabilities of survival. The results in correlation with experimental data on welded pipes made of various steels (22k, 15Kh2MFA, 08Kh18Ni10T), aluminum alloy (D16), and tungsten alloy (V95) reveal that the probability of failure, very low near zero for pipe joints under usually light load, is increased not only by high stresses in elbows and at brackets but also by the variance of numbers of cycles required for fracture. Considering that this variance increases with decreasing stress amplitude, it is expedient to use two safety factors for reliability design: a margin of cycles under large-amplitude stresses and a margin of stress under small-amplitude stresses. References 11 (Russian).

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EFFECT OF STRUCTURAL INSTABILITY AND OXIDATION ON HIGH-TEMPERATURE FATIGUE RESISTANCE OF HEAT-RESISTANT ALLOY

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 86
(manuscript received 14 Mar 84) pp 22-26

[Article by Ye.Ya. Paliyenko and A.D. Pogrebnyak, Mechanics Institute, UkrSSR Academy of Sciences, Kiev]

[Abstract] A study of the heat-resistant industrial nickel alloy E1437B was made for the purpose of determining the effect of structural changes and oxidation on its high-temperature fatigue resistance. Different structural states of this dispersion-hardening alloy were established after a standard heat treatment but before testing of specimens, by isothermal aging for 1000 h at various temperatures within its nominal service range of 970-1170 K. Smooth cylindrical specimens were then tested in a P391s machine for fatigue under pure flexure with rotation, with the load symmetrically alternating at a frequency of 50 Hz. The fatigue resistance was measured on a $3 \cdot 10^7$ cycles base at normal temperature (290 °C) and at the four aging temperatures (970, 1070, 1120, 1170 °C), tests being performed at 4-5 stress levels. Two batches of 15-20 specimens were high-temperature aged and fatigue tested, one batch with oxide surface film and one batch with class-10 surface polish. The data have been statistically processed for

plotting fatigue curves in accordance with the equation $\log N = c + m \cdot \log \sigma$ (N - number of cycles, σ - stress amplitude, c, m - calculated parameters). Microhardness was measured with a PMT-3 tester under a load of 0.05 N. The dependence of microhardness on both aging temperature and aging time indicates that it increases somewhat as the amount of the precipitating γ' -phase increases during the initial stage of aging (this initial stage becomes shorter with higher aging temperature and has vanished as the aging temperature reaches 1170 K) and then decreases during the next stage of aging characterized by grain growth of the γ' -phase. Metallographic examination has confirmed the difference between the trends of fatigue curves characterizing oxidized specimens and polished specimens respectively. An oxide film accelerates fatigue under large-amplitude stresses, accordingly, but the fatigue resistance under small-amplitude stresses is determined by the phase structure and not by oxidation. This agrees with the theory of oxidation kinetics, according to which oxidation is most intense at the beginning of high-temperature treatment under large stresses and, therefore, a polished specimen will oxidize quickly while an already oxidized specimen continues to oxidize much more slowly. References 4: 3 Russian, 1 Western (in Russian translation).

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CSO: 1842/193

UDC 539.4

STRENGTH OF INDIUM-TO-GLASS ADHESION AND METHOD OF ITS MEASUREMENT

Kiev PROBLEMY PROGNOSTI in Russian No 3, Mar 86
(manuscript received 12 May 83) pp 75-77

[Article by A.M. Magomedov, Dagestan University]

[Abstract] The life of indium-glass vacuum seals can be maximized by optimization of the sealing process, but controlling the adhesion strength is made difficult by the high plasticity of indium under a static load and its fracture without residual strain in an unfavorable environment. It therefore is necessary to control the environmental factors such as ambient temperature and humidity, glass surface finish, also heating and pressure as well as holding time during the seal formation process. In order to control these factors, it is necessary to measure the adhesion strength in the process. An apparatus has been developed and built especially for this purpose. It includes two 0.3 mm thick and 100 mm long steel strips joined at both ends to form a vertical hoop inside a frame, each strip carrying a tensoresistor as strain gage. The hoop is fastened to the frame at the top. A vertical rod fastened to the hoop at the top passes through a hole in the hoop diametrically opposite at the bottom and is coupled to the adhesion test cell underneath. The test cell contains a cylinder with a piston in the upper part and a heater coil around the conical lower part. The loading mechanism mounted on the frame under the

test cell includes a retainer, a glass disk, a movable cross-arm, and a flywheel. Measurements made with this apparatus have yielded data on the dependence of the indium-to-glass adhesion strength on the loading force, the loading time, the temperature, and the impurity content in indium. Addition of 3% Tl was found to improve that adhesion strength. References 6 (Russian).

2415/9835
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UDC 539.319

CERAMIC THERMAL INSULATOR IN STATE OF PLANE STRAIN

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 86
(manuscript received 30 May 84) pp 97-101

[Article by O.A. Batanova, T.Ya. Yershova and N.M. Naumova, High Temperatures Institute, USSR Academy of Sciences, and Department of Computer Mathematics and Cybernetics, Moscow University]

[Abstract] The problem of thermoelasticity is formulated and solved for a ceramic element, a long bar with rectangular cross-section rigidly mounted on a base to prevent displacements at both ends. This bar is heated uniformly over its entire length. The mechanical and thermophysical properties (tensile strength, compressive strength, modulus of elasticity, Poisson ratio, thermal conductivity, thermal expansivity) of the material, based on MgO or ZrO₂, are known and all except the Poisson ratio are strongly temperature-dependent. The ceramic body is therefore in effect a nonhomogeneous one and the problem is formulated accordingly for a plane state of strain. The corresponding conditions of equilibrium with the Cauchy relation and Hooke's law yield a system of differential equations, with the appropriate boundary conditions and symmetry. This boundary-value problem is solved by the variational-differences method with iterative sequential upper blockwise relaxation, utilizing the modular triple diagonality of the matrix of the difference equations. The algorithm of the solution has been programmed in FORTRAN for a BESM-6 high-speed computer. References 14 (Russian).

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UDC 666.263.2

KINETICS OF FRACTURE IN GLASS-CRYSTAL COMPOSITE SYSTEM

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 86
(manuscript received 14 Jun 84) pp 102-104

[Article by V.N. Dubovik, A.M. Raykhel, L.G. Ivchenko and O.A. Nepomnyashchii, Avtosteklo Plant No 25, Konstantinovka]

[Abstract] A model study of fracture kinetics in glass-crystal composite systems was made, for a better understanding of the devitrification process in glasses particularly susceptible to crystalline inclusions. Plates of commercial STM-1 glass and two experimental $MgO-Al_2O_3-SiO_2-TiO_2$ glasses were seeded separately with up to 700 μm large cordierite crystals, up to 500 μm large crystals of magnesium aluminosilicate, up to 350 μm large spinel crystals, up to 70 μm large mullite crystals, and up to 40 μm large rutile crystals. Plates of commercial AS-418 glass ($Li_2O-Al_2O_3-SiO_2-TiO_2$) were seeded with up to 2.0 mm large mullite crystals. The crystal concentration varied over the 16-410 cm^{-3} range. Inclusions were identified and monitored by petrographic and x-ray phase analysis. Fracture was induced by flexure in the 3-point configuration, with the pivot points 50 cm apart. The crack propagation was tracked on the basis of interference patterns and ultra-violet luminescence patterns. An analysis of these data as well as of available data on the linear thermal expansivity of glasses and crystals indicates that the mode of crack propagation and fracture in such composite systems is determined by the sign of thermal stresses. Compressive stresses in one phase cause preferential cracking under tension in the other phase. In the absence of thermal stresses, on the other hand, crack propagation is equiprobable in both phases. References 3: 2 Russian, 1 Western (in Russian translation).

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UDC 534.16:548.4

ACOUSTIC EMISSION DURING DEFORMATION OF HIGH-PURITY ALUMINUM SINGLE CRYSTALS

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 86
(manuscript received 14 Oct 84) pp 104-109

[Article by V.D. Natsik, Z.I. Bibik, S.I. Likhatskiy and V.V. Nerubenko, Kharkov State University and Strength Problems Institute, UkrSSR Academy of Sciences, Kiev]

[Abstract] Acoustic emission in 99.9997% pure aluminum single crystals under deformation at a constant rate was studied, for a determination of its dependence on the orientation of the tension axis. Specimens were grown in

a graphite crucible by the Bridgman method, on seeds cut from polycrystalline plates after rough rolling to an 80% reduction and annealing at 423 K for 1 h and subsequent cooling followed by finish rolling to final thickness. The orientation of each crystal was identified by the Laue method, whereupon its stereographic projection was plotted for determination of possible slip systems and the Schmidt factors. Acoustic emission signals were counted by a resonance-type transducer with a 200 kHz fundamental operating frequency as well as by a microstrip transducer with a 0.1-2 MHz operating bandwidth. Specimens were then tested mechanically in an "Instron TT-KM" machine with a movable active clamp producing a strain rate of $3 \cdot 10^{-3} \text{ s}^{-1}$. Metallographic examination was done under an MVT-71 microscope. The results are compared with analogous ones pertaining to equally pure polycrystalline aluminum and they confirm the feasibility of studying plastic deformation by the acoustic emission method. The authors thank D.A. Didenko for supplying the specimens and assisting in the experiment. References 15: 9 Russian, 6 Western (1 in Russian translation).

2415/9835

CSO: 1842/193

UDC 669.14.018:621.771

CRACKING RESISTANCE AS PERFORMANCE CRITERION FOR ROLLER STEEL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian
No 4, Apr 86 pp 57-61

[Article by M.Ya. Belkin, V.Z. Kamalov and L.M. Belkin, Kramatorsk
Industrial Institute]

[Abstract] The feasibility of improving the reliability of large bearing rollers by lowering the carbon content while increasing the silicon content and the vanadium content in the steel for roller bands has been established on the basis of a 7-factorial experiment. The seven 2-level arguments were %C, %Si, %V, %Cr, %Mo, quenching temperature, and tempering temperature. The three performance characteristics as dependent variables were hardness (on Rockwell C scale), resistance to plastic deformation under nonuniform compression (cylindrical specimens 5 mm in diameter), and toughness (prismatic specimens 210 mm long and 25x50 mm² in cross-section with 20 mm deep herringbone notch). Cracks were intentionally initiated by the hydraulic beater of an MUP-50 machine operating at a frequency of 1 Hz. The resulting regression equation was validated by five additional experiments at the center of the factorial space. These experiments yielded the mean values of the mechanical properties along with the standard deviations. The toughness was found to be most dependent on the tempering temperatures so that deviations of the latter ought to be minimized. The cracking resistance was evaluated according to the Peris relation $d_1/dN = C(\Delta K)^n$ (d_1/dN rate of crack growth, l - length of crack, N - number of cycles, ΔK - range of stress concentration coefficient, C, n empirical constants) on the basis of crack length measurements made after every 3000 flexure

cycles in a fatigue test with a 10^7 cycles base. The new steel 60KhSMF (0.55-0.65% C, 1.0-1.3% Si, 0.15-0.25% V, 1.6-1.8% Cr, 0.4-0.6% Mo) is tougher than the 9KhF steel now used. Its heat treatment must be adjusted to its composition, a higher than the nominal 900°C quenching temperature will compensate for deviations of %C, %Si, %V, %Cr, %Mo below the established ranges. Bands of 60KhSMF steel crack and chip much less than bands of 9KhF steel during grinding. Rollers with bands made of 60KhSMF steel are much more productive than rollers with bands made of 9KhF steel in a typical rolling operation. Bands of 60KhSMF steel are now produced at the Novo-Kramatorsk Machine Building Plant. References 6: 5 Russian, 1 Western (in Russian translation).

2415/9835
CSO: 1842/195

UDC 620.172.24

MECHANICAL PROPERTIES AND FRACTURE CHARACTERISTICS OF STEEL AFTER REPEATED THERMOMECHANICAL CASE HARDENING

Moscow METALLOVEDENIYE I THERMICHESKAYA OBRABOTKA METALLOV in Russian No 4, Apr 86 pp 61-63

[Article by N.K. Kryuchkov, Kuybyshev Planning Institute]

[Abstract] A study of repeated thermomechanical case hardening was made on four steels (carbon steels St25, St45 and alloy steels U10A, 30KhGSA) for the purpose of determining its effect on their mechanical properties and fracture mode. The treatment of cylindrical specimens 5 mm in diameter consisted of several cycles of plastic deformation and artificial aging. Plastic deformation was effected by rolling with a ball 5 mm in diameter, at a speed of 5.3π rad/s and a feed rate of 0.09 mm/rev under a force of 392 N. Subsequent aging at 110-150°C for 1.5-2 h, the temperature depending on the grade of steel, was to stabilize the high-energy state of the cold-worked surface layer. The mechanical properties were measured after 1-6 hardening cycles and loading in tension at a strain rate of $3 \cdot 10^{-5}$ s⁻¹ till fracture. The mechanical properties of such specimens were compared with those of specimens not hardened at all and of specimens hardened without subsequent aging. The mode of fracture was determined on the basis of macrostructural and microstructural examination. The results reveal that alternate rolling and aging raises the yield point as well as the proportional limit by 20-25% and the ultimate strength by 18%, increases the stability of all three properties, increases the fraction of isometric strain without significantly changing the total percentage elongation, while the percentage reduction decreases with an increasing number of treatment cycles. These results of mechanical tests are confirmed by fractograms, indicating a transition from fracture by pitting to fracture by spalling especially noticeable after the first 2-3 hardening and aging cycles. References 5: 4 Russian, 1 Western (in Russian translation).

2415/9835
CSO: 1842/195

COATINGS

UDC 621.793.722

DEPENDENCE OF SPRAY MATERIALS CONSUMPTION AND OF COATING PROPERTIES ON PROCESS PARAMETERS OF GAS-FLAME WIRE METALLIZATION

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 1, Jan 86 pp 5-7

[Article by Ye.N. Matveyshin, candidate of technical sciences, C.V. Kononov, engineer, A.S. Milichenko, engineer, and I.G. Kutsko, student, Zaporozhye Machine Building Institute imeni V.Ya. Chubar]

[Abstract] Gas-flame wire metallization is a new method of coating metal parts with corrosion-resistant or antifrictional wear-resistant layers as well as for rebuildup of worn parts or for correction of casting flaws. For a performance evaluation of this process in terms of product quality and material economy, it was studied in a factorial experiment with an oxyacetylene flame passing through size 1.2 or 3.4 nozzle and Np-65G high-carbon steel wire. Flat and cylindrical targets of low-carbon steel were placed at a distance of 80 mm from the nozzle orifice and moved lengthwise under it at a velocity of 0.4 m/s, with a transverse shift of 1.5 mm after each pass for the next one. The mass flow rates of acetylene and oxygen were measured with RS-3 rotameters. The pressures of acetylene, oxygen, and air were the three 3-level variable factors in the experiment. The wire material utilization factor was measured on flat specimens with surfaces which had been finished by abrasion pretreatment with steel shot, assuming a Gaussian distribution of metallizing flux. The hardness of coated cylindrical specimens was measured on the Rockwell C scale, and the bond strength of coatings was measured by the "pulling of a pin" method. After the statistical characteristics of the data have been established in terms of mean values and dispersions, a regression analysis yields equations for the three product quality indicators (wire material utilization factor, coating bond strength, coating hardness) as functions of the three variable process parameters. On this basis, both the wire material utilization factor and the coating bond strength will increase with higher air and oxygen pressures but lower acetylene pressure, while the coating hardness will increase with higher air pressure but lower oxygen and acetylene pressures. References 8: 6 Russian, 2 Western (both in Russian translation).

2415/9835
CSO: 1842/176

DEPENDENCE OF PROPERTIES OF TiNi INTERMETALLIC COMPOUND COATINGS ON
PARAMETERS OF SPRAY DEPOSITION PROCESS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 1, Jan 86 pp 7-8

[Article by N.V. Rogov, engineer, I.S. Geltman, candidate of technical sciences, V.I. Zotov, engineer, V.I. Pankov, engineer, and L.B. Gutkovskiy, engineer, Tulachermet Scientific-Production Association]

[Abstract] Coatings of a TiNi intermetallic compound, namely 55% Ti+45% Ni powder of the Class M 45-100 μm grain size fraction, were deposited on a flat surface by the plasma spray process. The purpose was to determine the dependence of the powder material utilization factor as well as of the coating porosity and hardness on the distance from plasmotron nozzle exit to coated surface. The performance of two plasmotrons was evaluated, a PP-25 plasmotron with self-sustained long arc and with Ar+N₂ or Ar+NH₃ as the plasma-forming gas mixture and a GNP-0.05/21 plasmotron with inter-electrode inserts and argon as plasma-forming gas. The spraying distance was varied over the 80-200 mm range and the powder material utilization factor as well as the coating quality characteristics were found to vary differently with each plasmotron and particularly with each plasma-forming gas. A high-enthalpy Ar+NH₃ gas mixture yielded the best coatings. Most efficient and economical was found to be the GNP-0.05/21 plasmotron with interelectrode inserts, with the powder fed into the nozzle-anode throat rather than through the entire nozzle-anode channel. References 3 (Russian).

2415/9835
CSO: 1842/176

EFFECT OF COLD WORKING OF BASE SURFACE ON PHYSICOCHEMICAL INTERACTION OF MATERIALS DURING GAS-FLAME SPRAY COATING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 1, Jan 86 pp 8-10

[Article by I.L. Kupriyanov, candidate of technical sciences, A.A. Verstak, engineer, I.S. Burov, candidate of technical sciences, and A.F. Ilyushchenko, engineer, Belorussian Republic Scientific-Production Association for Powder Metallurgy]

[Abstract] The effect of cold working of the base surface on the interaction of materials during the gas-flame spray coating process and on the coating bond strength is analyzed theoretically, on the basis of the theories of thermally activated chemical reaction and of plastic deformation in metals. Egress of dislocations into the contact zone and attendant formation of active coupling centers are treated as the principal

mechanisms. The effect of resulting higher dislocation density within the surface layer on the buildup kinetics of active coupling centers is established on the basis of applicable relations between bond strength and plastic strain. A qualitative evaluation indicates that pretreatment of a hot base surface by cold working can result in a much stronger or much weaker adhesion to it of coating particles deposited with a high impact velocity. The base surface will also become highly deformed as a result, even after hardening and formation of many active coupling centers within the contact zone. The surface of soft base metals such as copper and aluminum, as well as low-carbon steels, should be hardened before being coated, therefore, while the surface of hard metals such as high-carbon steels and refractory alloys should be annealed before being coated. These theoretical conclusions have been confirmed experimentally by deposition of alumina powder (50-63 μm grain size fraction), rutile powder (100-160 μm grain size fraction), and nickel powder (50-63 μm grain size fraction) on St45 steel after abrasive-jet surface pretreatment with corundum particles and on Armco iron after surface prehardening by blast. All specimens had been ground and then annealed at 600°C for 1 h under vacuum for stress relieving. References 6 (Russian).

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UDC 621.793.72:533.9

PLASMA-SPRAYED TiC_{x}N_z -BASE CERMET COATINGS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 1, Jan 86 p 13

[Article by M.Yu. Zashlyapin, engineer, and B.V. Mitrofanov, candidate of technical sciences, Chemistry Institute, Ural Scientific Center, USSR Academy of Sciences; N.V. Obabkov, candidate of technical sciences, and A.R. Bektov, candidate of technical sciences, Ural Polytechnic Institute imeni S.M. Kirov]

[Abstract] Coatings of $\text{TiC}_{x}\text{N}_z + 35\text{--}65\%$ Ni-Mo powders were deposited by the plasma spray process on surfaces of 20Cr13 and 15Cr11MoV steels which had been pretreated by abrasion with electrocorundum particles. Fine-dispersion powders of titanium carbonitride with Ni-Mo metallic binder had been produced by pregranulation, namely spraying and drying of their suspensions in 5% hexane solution of caoutchouc, then heat treated in a vacuum furnace for removal of the organic binder and hardening, and, finally, sintered. They were deposited with a GN-5R plasmotron and Ar+ N₂ as the plasma-forming gas mixture, to form 0.1-0.8 mm thick coatings. Subsequent heat treatment with an argon-discharge arc at 60-100 A current levels appreciably reduced the number and size of pores in the coating and at the coating-base interface. An x-ray phase analysis revealed slight oxidation and slight changes in the phase composition, with Ni-Mo intermetallic compounds and rutile as well as titanium carbonitride in all coatings. The microhardness

varied over the 11-21.2 GPa range, with the top level corresponding to TiC_xN_z inclusions and a decrease of the microhardness with increasing Ni-Mo binder content. Fatigue tests revealed a drop of the endurance limit, 400 MPa for 20Cr13 steel, by 8-10% after coating with any of the powder mixes. References 2: 1 Russian, 1 Western.

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UDC: 621.793

STRUCTURE AND PROPERTIES OF NI-CR-AL-PLASMA COATINGS FOR HEAT RESISTANT NICKEL ALLOYS

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 1, Jan-Feb 86
(manuscript received 23 Oct 84) pp 69-73

[Article by B.N. Guzanov, N.V. Obabkov, N.G. Belyankina and M.V. Khlynova, Sverdlovsk]

[Abstract] A study is made of the properties and structure of plasma powder coatings on nickel alloys. The Ni-Cr-Al coatings were obtained by atomizing PN85Yu15 and PKh40N60 commercial powders type. Comparative testing of various compounds containing 5 to 15% aluminum for sulfide corrosion and plasticity allowed optimization of a composition for deposition at a mixture of PN85Yu15 plus 20-40% PKh40N60. Defects in plasma coatings were found to prevent complete realization of the potential protective properties of the high temperature compounds, particularly in corrosive media. Laser melting of plasma coatings was found to achieve a uniform, homogenous coating with a transition zone, preferable for high temperature use. References 5: 4 Russian, 1 Western.

6508/9835
CSO: 1842/186

UDC 621.771.8

DIFFUSION PROCESSES IN BOUNDARY ZONE OF CORROSION-RESISTANT BI-METALS PRODUCED BY COLD CLADDING

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 86 pp 43-46

[Article by A.S. Mylnikov, A.A. Yershov and T.A. Sycheva, Ural Scientific Research Institute of Ferrous Metallurgy]

[Abstract] A study was made of bimets containing a layer of low-carbon steel bilaterally clad with corrosion-resistant steel. Of particular

interest are the diffusion processes across the boundary which occur after cold cladding and after subsequent annealing. Specimens of 12Kh18N10/08kp/12Kh18N10 steel sandwiches with a total thickness of 1.0 mm and 0.08 mm thick corrosion-resistant 12Kh18N10 cladding, produced at 200°C, were annealed at temperatures of 1000-1100°C for 1-60 min. The distribution of elements over a cross-section of the transition layer was determined slice-by-slice with the aid of a "Camebax" x-ray microanalyzer and an ARL-31000 vacuum-type spectral quantimeter. The data, including also results of metallographic analysis, have been evaluated on the basis of Fick's law and by solution of the corresponding one-dimensional equation of transient-state diffusion with the aid of the table of the primitive Cramp function. The carbon contents in the steel layers were measured by chemical analysis, diffusion of nickel and chromium was measured by x-ray spectral analysis. The results reveal that redistribution of carbon as well as of the alloying elements is possible only at the stage of recrystallization annealing. Annealing does not significantly increase the depth of chromium and nickel diffusion, the depth of chromium diffusion is slightly greater, with nickel forming a continuous solid solution in iron. Short annealing ensures recrystallization of the corrosion-resistant steel without lowering the bond strength between layers. Long annealing produces concentrational and structural nonhomogeneity in the boundary zone.

References 1 (Russian).

2415/9835
CSO: 1842/173

UDC 621.785.669.26:621.891

PROTECTION OF CONTACT PAIRS AGAINST SELF-WINDING BY MEANS OF DIFFUSION CHROME-PLATING

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 86 pp 46-47

[Article by I.L. Kopylova, V.A. Kuznetsov and Yu.D. Starostin, Moscow Institute of Civil Aviation Engineers and Central Scientific Research Institute of Machine Building Technology Scientific-Production Association]

[Abstract] Contact pairs operating at high temperatures in inert or reducing atmosphere, also under vacuum, cannot be protected against self-welding by galvanic chrome-plating or coating with a ductile alloy hardened by nitriding, carburizing, or silicidizing, because such protection fails already at temperatures below 400°C and is altogether not applicable to surfaces of intricate shapes such as those of gears. Diffusion chrome-plating has been proposed as a more effective protection. In a special study its effectiveness was evaluated for austenitic steel Kh18N10T and pearlitic steel 12Kh18F, this process being applied to specimens of both steels at a temperature of 1050°C in containers with a powder mixture of 50% Cr + 49% Al + 1% NH₄I and with fusible stoppers. Specimens without and

with chrome-plating were tested in a V-1-M container-type mechanical loading machine with measurement of the shearing stress, in an inert atmosphere of helium and in a reducing atmosphere of hydrogen under a pressure of 19.6 MPa in each case. Both gases had been purified of moisture by means of zeolites and alumina as well as of oxygen, to a residual level below 0.005% O₂, by means of a Ni-Cr catalyst. The tests have confirmed the adequacy of such a chrome-plating for 2000 h at temperatures up to 600°C under loads ranging from 10% to 80% of the 0.2% yield strength. References 2 (Russian).

2415/9835

CSO: 1842/173

COMPOSITE MATERIALS

UDC: 669-494:669.71.669-781

FORMATION OF COMPOUNDS OF CALORIZED BORON FIBERS WITH ALUMINUM MATRIX IN ROLLING OF FIBER COMPOSITE MATERIAL

Moscow FIZIKA I KIMIYA OBRABOTKI METALLOV in Russian No 1, Jan-Feb 86
(manuscript received 20 Oct 83) pp 99-103

[Article by B.A. Arefyev and S.O. Gevlich, Moscow]

[Abstract] A study is presented of the kinetic regularities of the formation of a strong bond between an aluminum matrix and calorized fibers during the manufacture of fiber composites by rolling in the direction of the fibers. The composite was produced by rolling assembled packets in the direction of allying of the fiber on a quarto mill with a roll diameter of 110 mm using a plasma bonded packet consisting of layers of boron fiber 140 μ m in diameter and AD1 aluminum matrix. The aluminum coating of Al_2 alloy was up to 5 μ m thick, applied to the fibers by drawing through a bath of melted aluminum. The boroaluminum composite was compacted by rolling 5 times at 300-500°C. The studies demonstrated the possibility in principle of producing a strong joint between the metallized fibers and aluminum matrix. Formation of the contact passes through two clear stages: establishment of physical contact and formation of the joint itself. In the stage of formation of physical contact, the force factor is important in the 300-450°C temperature range in a roll. The presence of the aluminum coating on the fibers decreases the energy cost of compacting. References 16: 15 Russian, 1 Western.

6508/9835
CSO: 1842/186

UDC 536.2+621.762.8

EFFECT OF INTERDIFFUSION OF COMPONENTS ON CONDUCTIVITY OF COMPOSITE MATERIALS WITH UNIDIRECTIONALLY ORIENTED REINFORCING FIBERS AND BARRIER COATING

Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 86
(manuscript received 5 Apr 85) pp 33-39

[Article by Yu.P. Zarichnyak and M.Yu. Malov, Leningrad Optics and Precision Mechanics Institute]

[Abstract] A physical model of composite materials with unidirectionally oriented reinforcing fibers and antidiiffusional barrier coating is constructed and an approximate mathematical model describing it is constructed for predicting the effect of interdiffusion during isothermal annealing on both thermal and electrical conductivities of the material. The physical model is based on a structural cell with a diffusion layer forming at elevated temperature either in the material during hot pressing or in the product under service conditions. The mathematical model of the diffusion kinetics is a partial differential equation in the one-dimensional radial approximation for three coaxial cylindrical regions (fiber, matrix, barrier), all assumed to be infinitely long in a cable configuration, with appropriate boundary conditions. Solution of the system of the correspondingly three such equations, simplified by assuming a barrier layer much thinner than the fiber, yields the concentration profiles of the components and, with the effective thermal and electrical conductivity of each component known, also the effective conductivity of their solid solutions. Calculations of the integral characteristics of the composite material on this basis reveal that interdiffusion, even across thin layers, does in time appreciably decrease the effective conductivity of the composite material and especially so in the direction perpendicular to the fiber axis.

References 16: 12 Russian, 4 Western.

2415/9835
CSO: 1842/182

UDC 621.762.001

THERMAL EXPANSION OF CARBON-ALUMINUM COMPOSITE MATERIAL

Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 86
(manuscript received 27 Nov 84) pp 74-76

[Article by I.M. Zhitkikh, A.A. Zabolotskiy, A.T. Manuylov, M.I. Morozova, V.N. Baturin, A.V. Khromov and B.F. Trefilov, Moscow]

[Abstract] Composite materials with a matrix of Al-Zn-Mg aluminum alloy and carbon fibers have better elasticity and strength characteristics than the aluminum alloy alone and, at temperatures above 150°C, also better

than those of carbon-plastics. An important property determining the usefulness of a structural material for power equipment is its coefficient of linear thermal expansion, which should generally be low. This property of the composite material with 45-50 vol.% carbon fibers was determined for 4 mm thick 70x180 mm² large plates which had been produced by impregnation under pressure, with an orthotropic reinforcement pattern of layers with alternate longitudinal orientation and transverse orientation of fibers. Measurements were made in an RNP (Japan) DL-1500 thermal dilatometer, using 15 mm long bars with 4x4 mm² cross-section cut lengthwise from those plates and heating them in an infrared furnace at a rate of 5°C/min. The temperature of a specimen was measured, accurately within 3±%, with a Pt/Pt-Rh thermocouple. Its length was measured with an inductive transducer under a vacuum with lower than 2.66 Pa residual pressure. The readings of the coefficient over the temperature ranges 20-100°C, 20-200°C, 20-300°C, 20-400°C, 20-500°C, 100-200°C, 200-300°C, 300-400°C, 400-500°C were compared with already available data for the same composite material with only longitudinal orientation or only transverse orientation of all fiber layers. On the basis of the results, the orthotropically reinforced composite material is adequate for structures subject to severe dimensional stability requirements. References 2: 1 Russian, 1 Western.

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UDC 621.762

SUPERFICIAL SEGREGATION OF ATOMS IN ULTRAFINE-DISPERSE Ag-Cu ALLOY POWDER

Kiev POROSHIKOVAYA METALLURGIYA in Russian No 3, Mar 86
(manuscript received 22 May 85) pp 100-102

[Article by Yu.M. Shulga, A.S. Ivanov, V.I. Rubtsov, V.Ya. Ganelin, Yu.G. Borodko, L.I. Trusov and V.N. Lapovok, Chemical Physics Institute, USSR Academy of Sciences]

[Abstract] Segregation of Ag and Cu atoms in ultrafine-disperse Ag+Cu alloy powder was measured by both x-ray photoelectron and Auger spectroscopy using a MgK_α-radiation source. Specimens had been produced by the method of evaporation and condensation in an inert atmosphere, examination under an electron microscope indicating spherical grains of 30 nm average size. An important consideration in this study was the limited solubility in the solid phase, only 10% Ag dissolving in copper at high temperatures and almost none at room temperature. Supersaturated metastable solid solutions were obtainable, however, under nonequilibrium conditions such as during cooling at rates of the order of 10⁴°C/s. The silver content at the surface was determined from the results of chemical analysis and was correlated with readings of the lattice parameters, all of the latter having been found to be enlarged but not having been found to depend monotonically on the Ag concentration. The ratio [Ag/Cu]_{atom} on the powder surface was

determined from the integral intensities of the Ag3d line ($E_{kin}=885$ eV) and the CuL₃VV line ($E_{kin}=900$ eV), with linear approximation of the background intensity. The ratio of these intensities was found to be 2.3 for $[Ag/Cu] = 1$. It was difficult to identify the silver oxides, Ag_2O being particularly rapidly reduced at the powder surface during exposure to x-rays under vacuum, but the photoelectron spectrum revealed Cu2p copper and the Auger-electron spectrum revealed L₃VV copper existing in discernible Cu^{2+} , Cu^+ , Cu^0 states. According to the degree of copper oxidation, all alloy powder specimens could be classified into two groups: those coated with a Cu_2O layer and those containing metallic copper coated with a CuO layer. Both electron spectra of the first group do not contain a satellite. The second group is characterized by a satellite in the photoelectron spectrum, its intensity being lower than that of the CuO satellite, and additional peaks in the Auger-electron spectrum. While x-ray structural analysis confirmed the presence of metallic copper and of CuO traces in the second group, it did not reveal much Cu_2O . Evidently a protective CuO film inhibits further oxidation. It did not confirm the presence of Cu_2O in the first group, this high-temperature oxide being amorphous here.

References 8: 3 Russian, 5 Western.

2415/9835
CSO: 1842/182

CORROSION

IMPROVING ANTI-CORROSION PROTECTION OF METAL

Moscow IZVESTIYA in Russian 24 Dec 85 p 2

Article: "Price of Protection--What Prevents Us from Conquering Corrosion?"

Text Academician Ya. Kolotyrkin, the director of the Scientific Research Physicochemical Institute imeni L. Ya. Karpov proposes a broad set of measures aimed at improving the anti-corrosion protection of metal.

There are two scales whose balance is intended to be effective management. On one scale are capital investments aimed at creating new funds and on the other are those that are going to support existing assets in working condition. Any underestimate of capital savings hinders the intensification of the production processes. A very serious question arises right here which in the draft Basic Directions, in our view, ought to be far more forcefully stressed.

The reliability, materials-intensity, and effectiveness of productive capital and of the most important industrial products are determined mainly by the level of their anticorrosion protection. If this is inadequate, corrosion sharply reduces the service life and operational reliability of structures and equipment and their failures involve large inefficient expenditures of labor, power and other resources. In order to provide reliable protection, the required proportion between the growth of the metal stock and the volume of materials production on the one hand and the means of protection on the other, must be observed.

As long ago as 1975, research conducted by NIFKhI/Scientific Research Physicochemical Institute imeni L. Ya. Karpov demonstrated that this proportion is being significantly disrupted. As a result, up to 25 million tons of metal structures and other items, affected by corrosion, are annually being sent to ahead-of-schedule remelting. The total amount of all direct and indirect losses and additional expenditures in connection with this have approached, according to an expert estimate, 40 billion rubles per year.

Since that time, a further decrease in the level of anti-corrosion protection has occurred. Providing the national economy with the means of protection from corrosion and with equipment for this use now amounts to from 10 to 40 percent of the really required norm. In particular, the production of paint

and varnish materials covers only 40 percent of the necessary amount, polymeric chemically-stable materials for protective coatings--35, inhibitors--10-15, rolled metal with protective coatings--30, modern galvanizing and coloring equipment--30, and control instruments--5 percent in all.

However, it must be kept in mind that the technically required level of protection will sharply increase as soon as we begin to really lower the metal-intensity of items. High-strength materials are generally far more sensitive to the quality of anti-corrosion protection. In addition, with the switch to them, the usual allowances for corrosion which up to now have often made up for poor protection also have to be eliminated.

Many of the most important technical tasks will turn out to be unrealizable if in the 12th Five-Year Plan the development and outstripping industrial output of materials and means of protection from corrosion are not provided. This is a multi-level state problem but it can be fully solved with a clear understanding of the causes which have prevented a solution up to the present time.

The production of materials and means of protection is still being dispersed through enterprises of many industries and, as a rule, it is not their main production. Therefore, this is precisely why, for example, the introduction of capacities at the Tambov Galvanizing Equipment Plant(Minstankoprom/Ministry of the Machine Tool and Tool Building Industry) and at a number of other plants has been stretched out for decades. It seems to be advisable to concentrate all such production units of both a machine building and a chemical type, at large specialized and well-coordinated enterprises.

USSR Gossnab/State Committee for Material and Technical Supply allots funds for such production in accordance with the ministry's requests without calculating the effectiveness of their utilization. It is necessary to allot them first of all to those industries where protection from corrosion is especially important: chemical and petrochemical, the agroindustrial complex, transportation, and the extraction and transporting of oil and gas.

Of course, it is no less important that the enterprises themselves are vitally interested in the high quality and reliability of production output. Then they will immediately feel their own material responsibility also for reducing losses from corrosion and for their correct calculation at all stages of public production. The formally established anti-corrosion services are not now fulfilling their functions, they are few in number, and poorly equipped. At the enterprises which are suffering great losses from corrosion, there are not even attempts to set up the post and service of chief corrosionist that are provided with suitable rights and responsibility (modeled on the services of chief welder, chief technologist, etc.).

The necessity has also matured for creating in the system of Gosgortekhnadzor/State Committee of the Council of Ministers for Supervision of Industrial Safety and for Mining Inspection a special organ for controlling the level of equipment protection, registering large-scale corrosion failures and breakdowns of this equipment, analyzing their causes, and guiding the appraisal of planning documentation.

The All-Union Intersectorial NII [Scientific Research Institute] for the Protection of Metals from Corrosion of the GKNT [State Committee of the USSR Council of Ministers for Science and Technology] must play an important role in solving the problem discussed. Gathering into itself the most qualified specialists, it has been called upon to give scientific and technical assistance to industry, to develop the most effective methods of protection and tests, and to organize and coordinate many-sided special purpose programs of fundamental and applied work. Unfortunately, this has not happened.

The institute has not accomplished a number of important undertakings (the creation of an all-union bank of corrosion data, over-all planning proposals for the production of means of anti-corrosion protection). Recently it is simply not up to doing its own work, squandering itself on the small-scale introduction of incidental, strange, obsolete developments which at times are not related to corrosion.

At the same time the truly intersectorial important problems on which the future of anti-corrosion protection depends, remain outside of its interests and horizon. Such, for example, is the problem of surface, anti-corrosion alloying. The point is that instead of a haphazard thermal application of protective metallic coatings, i.e., external ones of easily destructive formations, an industrial technology is used which permits the alloying of an already practically finished product or semimanufacture to a prescribed required depth, adequate so that the necessary corrosion stability is organically provided for the whole period of operation.

Excluding the unnecessary alloying of the bulk of an item which is never in contact with a corrosive medium, this method opens the way for a genuine effective technology of the future. With the same resources, it will permit a sharp reduction in cost and an expansion of anti-corrosion alloying with such most effective but scarce elements like chrome, nickel, molybdenum, and titanium. Using the special properties of the carbides of these metals, the highest over-all stability against corrosion and wear and, at the same time, the preservation of the supporting and resilient characteristics of the most high-strength material can be achieved. Neither has been attainable for the bulk-alloying of corrosion-resistant alloys.

In spite of the total indifference of the Institute for the Protection of Metals from Corrosion and the GKNT, the problem of surface anti-corrosion carbide alloying has recently rallied around itself a full-of-initiative complex of other research organizations including the NIFKhI imeni Karpov, the Kharkov NPO [scientific production association] Karbonat, the Kharkov Polytechnical Institute, the Ukrainian NII of Special Steels. The fact that such an advanced enterprise of the country as the Sumy Machine Building Plant imeni Frunze has actively taken up this work, allows one to hope for their successful development, although the concentration of scientific forces here is still inadequate.

This is only one of a great number of new directions of anti-corrosion technology connected with thorough fundamental study. Who will coordinate and lead them? Life demands an answer to this question.

It is impossible to also avoid talking about the problem of personnel. The horizon of a good corrosion protection specialist must be sufficiently broad. It includes general purpose knowledge of physics, chemistry, materials technology, effective designing, technology, and economics. At the same time very many workers in production and the administrative apparatus of ministries must now have a specific minimum amount of knowledge in the field of anti-corrosion protection. Therefore it is necessary in the Minvuz [Ministry of Higher and Secondary Specialized Education] and industry advanced training system to create centers for training and giving additional training to specialists in this field. Meanwhile the demands of the ministries are not even being covered by that small output of specialists which the VUZ's [higher educational institutions] are now accomplishing.

The time has also come for serious improvement in the structure of the anti-corrosion service in the country, including an increase in the responsibility of GKNT, the creation in Gosplan [State Planning Committee] and Gossnab USSR of subunits directly responsible for the production and distribution of corrosion-resistant materials, equipment, and other means of protection from corrosion.

In connection with all that has been said above, in Part II of the draft of the Basic Directions, in the paragraph "To significantly speed up the development of machine building," it is necessary to give the more precise definition: "to accomplish a fundamental increase in the technical level and primarily the service operating life and reliability of production output." Paragraph: "to provide thorough qualitative changes..." -- to add the phrase: "to ensure the accelerated output of new highly-effective materials and means of protection from corrosion, the introduction of new technological processes of anti-corrosion protection, an increase in the operating life and reliability of machines, equipment, metal structures, underground service lines and means of transportation."

In Part IV, in the paragraph "More fully utilize..." insert after "construction" the word "corrosion-resistant."

In Part V, in the introductory part, after the words "progressive construction materials" suggest adding the words: "equipment and means of protection from corrosion."

In the same part, in the chapter "Machine Building Complex," in the paragraph "to increase the use in machine building of progressive construction materials..." after the word "plastics" insert the addition: "metallic materials with protective coatings, new technological processes of surface alloying, the application of galvanizing and other coatings."

Still another addition in Part V, in the chapter "Production of Construction Materials" at the end of the first paragraph: "to provide a broadening of the output of rolled metal with protective surface alloying and coatings, paint and varnish and polymer materials, inhibitors and other materials for protecting equipment and structures from corrosion." In the same place, in the paragraph "Provide the Rapid Development...", after the words "used for technical purposes," the suggestion is to add: "inhibitors of corrosion." The addition: "to expand the output of lubricating oils, including ones with anti-corrosion additives" ought to be added in the chapter "Power-Fuel Complex."

UDC 621.791.052:[669.293+669.14.018.8]:620.193.56:546.175-323

CORROSION RESISTANCE OF WELDED NIOBIUM-TO-STEEL JOINTS IN BOILING HNO₃

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 1, Jan 86 pp 22-24

[Article by G.D. Nikiforov, doctor of technical sciences [deceased], Ye.N. Sivov, candidate of technical sciences, N.P. Krutogolov, candidate of technical sciences, and N.Ye. Sivova, student, Moscow Aviation Technological Institute imeni K.E. Tsiolkovskiy]

[Abstract] The corrosion resistance of welded joints of VN-2AE niobium alloy to 12Cr18Ni10Ti stainless steel in boiling 65% aqueous HNO₃ solution was measured, including proneness to intergranular corrosion and general corrosion resistance. Specimens of 0.5 mm thick sheet pairs and 2 mm thick sheet pairs were welded under different heat cycles with and without an interlayer of intermetallic compounds. With an Rz=2.5 μ m surface finish and having been degreased, specimens of welded pairs were weighed on an analytical balance accurately within ± 0.1 mg before immersion in boiling HNO₃ solution for three 48 h cycles. The base steel and the welding seams had retained their dark-brown coloration, while the niobium alloy had retained its metallic luster after 96-144 h. An evaluation of gravimetric readings indicates no corrosion of the niobium alloy, after formation of a protective film within the first 48 h. The joints without interlayer of intermetallic compounds were found to have the same corrosion resistance as the base steel. The joints with interlayer of intermetallic compounds were found to have a much lower corrosion resistance down to one half, owing to dissolution of niobium in the seam metal. References 7 (Russian).

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PROTECTIVE PROPERTIES OF COMPOSITES (STEEL POWDER ALUMINUM COATINGS)
OBTAINED BY COMPACTING ELECTROPHORETIC AND ELECTROSTATIC PRECIPITATES

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 1, Jan-Feb 86
(manuscript received 3 Aug 84) pp 104-109

[Article by V.N. Polyakov, V.P. Karshin, V.N. Geminov and L.K. Gordiyenko,
Moscow]

[Abstract] Powdered aluminum coatings were obtained by compacting electro-phoretic and electrostatic precipitates. The mechanical properties of type 40 Kn steel with an aluminum powder coating were found to remain unchanged after holding in a solution of hydrogen sulfide for 1000-2000 hours. Complete protection from hydrogen embrittlement and corrosion cracking was achieved. In neutral NaCl solutions the aluminum coating has areas of active dissolution and breakdown, but not passivation. All methods of coating tested were found to have advantages and disadvantages. The high protective properties of the coatings are related to specific features of their structure, such as fine grain, short intermetallide transition zones, good adhesion, absence of open pores, and very slight closed porosity. Hydraulic impulse aluminum coatings are considered promising for corrosion protection in corrosive media. References 14: 12 Russian, 2 Western.

6508/9835
CSO: 4842/186

FERROUS METALS

NEW HORIZONTAL STEEL-TEEMING EQUIPMENT

Moscow PRAVDA in Russian 10 Feb 86 p 1

Article: "New Channel for Steel"

Text Our stringer correspondent V. Ryzhkov has informed the editorial office that the first installation in the country for teeming steel by the fundamentally new horizontal method is being tested at the metallurgical combine.

Until recently metallurgists were acquainted with only two types of machines used for casting blanks--vertical and radial action. Reliable in operation, they nevertheless also have significant shortcomings: both have low productivity, are bulky, and require huge costs during construction. Now a new installation has appeared. How does it differ from its predecessors?

"Enviable efficiency," says the Deputy Director of the Karaganda Metallurgical Combine G. Epov. "The installation being tested is more than three times as productive as those that we are now using. It is compact and versatile and can even be set up in this room with ease. It practically has no 'underground floors'."

The installation has been in operation for less than a year at the Karaganda Combine. The specialists are convinced that it has saved the enterprise several million rubles during this time. Manual labor has almost been eliminated here.

8524
CSO: 1842/144

LARGEST BLAST FURNACE YIELDS FIRST PIG IRON

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 15 Apr 86

[Article by V. Minin: "'Northerner'--In Operation"]

[Text] Yesterday a work holiday came to the city on the Sheksne. The name-day celebrant, arrayed in red calico, was the fifth blast furnace of the Cherepovets Metallurgical Combine, "Northerner," as its construction engineers, metallurgists and all the Cherepovets inhabitants fondly call it.

"How is it going for you there at the 'Northerner'?" In the last few days we have been asking everyone returning from the construction project. We heard in answer:

"The drier is set up . . ."

"It's stoked with wood to heat it up . . ."

"They have finished feeding the charges . . ."

And so the state commission permitted the start-up of the largest blast furnace in the world to begin. Yu. Lipukhin, director of the combine, gives the "o.k." to feed the hot blast into the furnace. Through the inspection hole of the tuyere one can see, from the red-hot blast spout simultaneously there burst out under the layer of the batch about 1000 cubic meters of birch wood--such a giant bonfire, from which coke is ignited and the continuous blast furnace smelting begins.

Everyone present at this moment at the casting bed--metallurgists, construction workers, installation workers--congratulates each other on the labor victory, with the start of operation of the fifth blast furnace.

Hand in hand they have proceeded for years toward this victory: splendid construction workers, brigade leaders V. Rozov and N. Smirnov, installation workers, heroes of Socialist Labor A. Myshenkov and Ye. Valuyev and metallurgists --furnace chief B. Kurlikov and senior blast furnace attendants P. Malyshев and P. Berdnikov.

One joyful moment and 10 long years! Thus long have the minds and hearts of the people been occupied with this blast furnace, which has been destined to become henceforth the flag bearer of the country's ferrous metallurgy.

"The first blueprints of the fifth blast furnace appeared in 1976," recalls A. Suslov, to whom, in the role of chief design engineer, it fell to head the development of blast furnace No 5 in Lengipromez. "The designing was carried out under very complex conditions, mainly due to the restricted nature of the construction site."

One can understand the designers: they had to "seat the object" almost in the very center of the existing metallurgical combine. For this they had to tear down and transfer dozens of objects and utility lines and build a new unit without shutting down the blast furnaces operating alongside.

It is difficult to refrain from giving some of the main figures characterizing the volumes of work fulfilled by the general contractor--the All-Union Cherepovetsmetallurghimstroy Association--and the specialized organizations of the USSR Ministry of Installation and Special Construction Work. The complex of the fifth Cherepovets blast furnace consists of over 200 objects, for the construction of which it was necessary to shift 14 million cubic meters of earth and to lay 570,000 cubic meters of monolithic and 165,000 cubic meters of precast reinforced concrete, to assemble 170,000 tons of metal structures and over 40,000 tons of industrial equipment and to lay dozens of kilometers of railroad tracks and motor vehicle roads. Hundreds of kilometers of water drainage systems, conveyors, channels, air conduits and power systems link together this complicated industrial complex. It can rightfully be called a pig-iron-smelting "plant within a plant", having its own railroad station and its own river moorings with warehouses to receive iron ore raw material, its own central heat and power plant and electric blast station and its own independent system to feed and purify water.

One could speak at great length and say many things about the country's main blast furnace. It is the offspring of the collective--the entire country built the furnace. There were many discussions of all kinds at all levels and stages of construction. I recall the year 1977, however, when the technical-economic council of the USSR Ministry of Ferrous Metallurgy met in the reading room of the blast furnace shop at the Cherepovets Metallurgical Combine in April. There were many Cherepovets blast furnace attendants and chiefs of all the blast furnace shops in the country there. There was one single problem: discussing the structural decisions for the fifth blast furnace. Specialists from Lengipromez gave reports.

"The blast furnace is to operate up to the year 2050," said V. Vanchikov, chairman of the technical-economic council and the then former deputy minister, "fill us with ideas on structural designs for the blast furnace."

A great deal was suggested, particularly with respect to automating the process, facilitating the work of the blast furnace attendants and improving the work conditions for the blast furnace operators and protecting the environment.

"A large part of what was outlined and proposed at that time has today become a reality," says V. Netronin, chief blast furnace operator of the Cherepovets Metallurgical Combine. "Under the direction of our general planning director the collectives of 17 planning institutes and about 100 specialized planning organizations developed the furnace. In many ways they took our wishes into account, and correlated and used domestic and foreign experience in construction of extremely large blast furnaces, so that it could be said that the "Northerner" is the last word in technical thought in blast furnace production.

A number of inventions were registered in just the course of planning and construction. The chief one, however, is perhaps the fact that the unique complex was constructed according to the modern principle of wasteless technology. The slag, slime and blast furnace gas--everything that formerly went into the dumping ground and polluted the environment--all this at the "Northerner" is converted into secondary raw material resources and will be immediately put to use; granulated slag, for example--as a valuable raw material for construction, blast furnace gas--as fuel for the boilers of the heat and electric power station of the same blast furnace. The planners estimated that for the production of each ton of pig iron, due to realizing the "secondary product" the combine will have approximately two rubles profit. This is 7-9 million rubles a year in the coin box of the economy, not counting the most important thing--protecting the environment.

"Here at the casting bed, which encircles the furnace with a wide ring, everything has gone into motion. The main command of the furnace foreman rings out: "Drill the tap hole!"

The party committee of the blast furnace shop directed the best foremen B. Kurlikov, N. Ziganshin, L. Ostapenko and V. Dorokhin to developing the giant blast furnace. Brigades of blast furnace operators were headed by shop veterans and first blast furnace operators P. Berdnikov, V. Kotov, P. Malyshov and S. Nadeyev, of whom each is worthy of directing the first output of pig iron. This honorary right today, however, fell to the lot of the most fortunate. Of course, they are nervous, worrying behind them are those who, as honored guests attend the first output of pig iron--the construction workers, installation workers and steel workers from the open-hearth and convertor shops, who are to take the pig iron of the furnace for further conversion. Among the guests of the "Northerner" hosts today are also workers in related fields--miners, railroad workers and river workers. They are to "feed" the furnace--to feed to the main conveyor every day charges of up to 400 carloads of raw materials.

...The casting bed is illuminated with the brilliant gleam of red-hot metal. Accept, Motherland, the first pig iron of the "Northerner."

12151
CSO: 1842/191

TIGHTER SCHEDULE FOR STEEL OUTPUT

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 11 Apr 86 p 1

[Article by P. Laptev: "On a Tighter Schedule"]

[Text] Less and less time remains until the start-up of the first section of the dynamo steel shop at the Novolipetsk Metallurgical Combine imeni Yu.V. Andropov. This also determines the rhythm of the construction today--the schedules have been tightened to the maximum. Recently the main substation yielded current and one more thermal furnace was placed on load. The brigade of Hero of Socialist Labor B. Grigor'yev completed the installation of the four-high rolling mill ahead of schedule. It is the heart of the new shop and is therefore being paid particular attention.

One-third of the objects of the construction project are already under pre-launch conditions. The main task now is--by the middle of April to fully prepare the work front for subcontracting organizations.

12151
CSO: 1842/191

UDC 621.787.4:669.14

COMPOUND MICROALLOYING OF LOW-PEARLITE STEELS FOR CONTROLLED ROLLING

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 86 pp 10-17, 23

[Article by Yu.I. Matrosov, Central Scientific Research Institute of Ferrous Metallurgy imeni I.P. Bardin]

[Abstract] A study was made which has led to the development of series 09G2 low-pearlite steels (0.08-0.11% C and 1.2-1.6% Mn) for large-diameter gas pipelines for the Far Northern regions. Compound microalloying with three carbonitride-forming elements (V, Nb, Ti) has been optimized so as to ensure most economically an additive favorable effect on strength and plasticity of steels for subsequent controlled rolling and no significant lowering of the yield point with the aluminum content raised from 0.01% to 0.1%. An additional favorable effect of these three microalloying elements is higher ductility and resistance to brittle fracture as well as to cold shortness. The additive compounding of their effects has been confirmed by a comparison with the effect of microalloying steel with each element separately. The effectiveness of compound microalloying was finally tested by rolling under controlled conditions, favorable grain orientation and favorable temperature characteristics of mechanical properties being the principal criteria for setting both initial and final rolling temperatures. The effect of hot rolling has, moreover, been found to exceed the effect of normalizing and to superadditively compound the effect of microalloying.

References 9 (Russian).

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CSO: 1842/173

INDICATORS OF FATIGUE FRACTURE IN METAL THREAD MADE OF U9 STEEL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 86 pp 34-35

[Article by Yu.A. Koptev, V.V. Shestakov and L.P. Kryuchkov]

[Abstract] For a performance analysis of water hoses made of U9 steel threads and operating under a static pressure of 21 MPa with small fluctuations, such threads were tested for fatigue resistance. Tests were performed in a built-up UK1-10M machine for micro- and macroindicators of fracture under combined constant tension and alternating flexure. Static tension was applied by a spring set for testing at three stress levels ($500\text{-}750\text{-}1000\text{ N/mm}^2$) and cyclic flexure was produced by rotation of a camshaft at 3000 rpm. Microfractographic examination of cleavage surfaces under a JSM-T200S scanning electron microscope revealed fracture of threads in only one section perpendicular to the thread axis. The structure of cleavage surfaces differed depending on the magnitudes of tensile and flexural stresses as well as on their ratio. Folding with subsequent rupture and secondary cracking was found to occur within $4.5\cdot10^3$ cycles under a tensile stress of 1000 N/mm^2 and a flexural stress of 1500 N/mm^2 amplitude. Fatigue characterized by microfolds in the slip planes and followed by ductile fracture by merging of micropores was found to occur within $3.17\cdot10^6$ cycles under a tensile stress of 500 N/mm^2 and a flexural stress of 800 N/mm^2 amplitude. Analogous tests performed on threads of the more ductile VNS-9 steel revealed fatigue fracture at all stress levels. References 1 (Russian).

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CSO: 1842/173

DEPENDENCE OF MECHANICAL PROPERTIES OF Cr12Mo STEEL ON INITIAL STRUCTURE, HEAT TREATMENT, AND DEFORMATION PROCESS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 4, Apr 86 pp 8-10

[Article by V.A. Yevstratov, V.I. Yeremin and V.M. Pivovarov, Kharkov Polytechnic Institute]

[Abstract] A study of Cr12Mo steel for heavy-duty forming tools such as dies and punches was made, its purpose being to improve their mechanical properties by optimizing the heat treatment and the subsequent plastic deformation depending on the structural state of blanks as delivered. An empirical relation between hardness after annealing and mean size of the pearlite grains had been established on the basis of statistical data and

their analysis, with the mean size of carbide grains maintained standard and constant throughout so as to eliminate it as an influencing factor. Specimens were heated to various temperatures ranging from 900°C to 1140°C and held at each for 20 min before quenching and subsequent tempering at 200°C for 1 h. The quenching temperature for maximum hardness was found to depend on the pearlite grain size. Specimens were plastically deformed by hot rolling and by hot upset forging. The results indicate that maximum hardness and tensile strength are attainable by quenching from 1020-1050°C and forging to 25-30% reduction with the end temperature not lower than 870°, then air cooling. Such a treatment produces a most uniform and thus most favorable grain distribution. References 4 (Russian).

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UDC 669.14.018.252.3:621.178.385

IMPACT-FATIGUE STRENGTH OF CAST AND WROUGHT HIGH-SPEED TOOL STEELS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 4, Apr 86 pp 10-12

[Article by V.Ye. Cherkasov, N.M. Yakshin and I.M. Kavitskiy, PROYEKTIN Tula Planning-Design and Technological Institute for Combine Building]

[Abstract] An experimental study of cast and wrought R6M5 and R18 steels for high-speed cutting tools was made, its purpose being to determine their fatigue strength under repetitive impact. Chipping of teeth had already been established as the main cause of failure of milling cutters, typically those with 7.3 mm wide teeth on 160 mm diameter hubs. Fatigue tests were performed in a special apparatus, whereupon the mode of fracture was determined on the basis of macrofractographic analysis under an MVS-2 microscope with an MFN photographic attachment (x16 magnification) and microfractographic analysis under a JSM-3m scanning electron microscope as well as under an EMV-100LM transmission electron microscope (variable magnification). The results indicate that a cast steel has a higher fatigue resistance than a wrought steel under impacts of 0.47-0.60 J energy typical of milling tools. Measurements of changes in electrical resistance during fatigue tests and electron-diffraction analysis of cleavage surfaces have revealed significant changes in structural behavior under load, an anomalous redistribution of ledeburite in cast steel facilitating stress relaxation and thus postponing initiation of cracks. References 9 (Russian).

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DEPENDENCE OF PROPERTIES OF ONI6 STEEL ON HEAT TREATMENT

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 4, Apr 86 pp 13-15

[Article by B.P. Sharov, N.I. Karchevskaya, G.A. Tolmacheva, L.I. Gladshteyn, and V.V. Pavlov, Central Scientific Research Institute of Ferrous Metallurgy imeni I.P. Bardin, Central Scientific Research and Design Institute for Construction Metalwork, and Orsk-Khalilovo Metallurgical Combine]

[Abstract] An experimental study of ONI6 steel (0.08% C, 6.5-7% Ni, 0.36-0.38 Mn, 0.25-0.30% Si, 0.02% Al, 0.02% Nb, 0.009-0.011% P, 0.007-0.009% S) for isothermal liquified-gas storage tanks was made, its purpose being to determine the dependence of their mechanical properties on the heat treatment. Three modes of heat treatment were tested: 1) air quenching from 900°C after 0.5 h and again from 790°C after 0.5 h with subsequent tempering at 600°C for 2.5 h, 2) air quenching from 900°C after 0.5 h and again from 790°C after 0.5 h with subsequent heating to and holding for 2.5 h at 670°C, 3) air quenching from 850°C after 0.5 h with subsequent heating to and holding for 2.5 h first at 740°C and then at 670°C. Ultimate strength and yield strength did not depend significantly on the heat treatment, but percentage reduction increased after the third heat treatment. Cold shortness depended on the heat treatment, being reduced most by the first heat treatment mode. The isothermal transformation diagram and the results of microstructural examination with the aid of electron microphotography indicate that heating to and holding first at 740°C for 30 min and then at 670°C for 2.5 h will ensure the optimum composite of mechanical properties with minimum but still high cold shortness. The latter is made inevitable by presence of fine-grain stable austenite uniformly distributed in the ferrite phase. References 4: 1 Russian, 3 Western.

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STEELS FOR CRYOGENIC POWER EQUIPMENT

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 4, Apr 86 pp 29-31

[Article by B.S. Yermakov, A.Ya. Nikolaich and V.A. Oparin, Leningrad Polytechnic Institute]

[Abstract] Steels containing 0.9% C and 30% Mn, plain (90Mn30) and alloyed with 2-11% Al ((0Mn30Al2,4,6,8,10,11), were studied for usability in cryogenic

equipment. They were smelted in an open induction furnace with basic crucible and then, for removal of nonmetallic inclusions, remelted by the electroslag process. Ingots were forged into rods 15 mm in diameter and those were quenched from 1050°C in water after 45 min. The magnetic permeability in an external field of 620 kA/m intensity as well as the mechanical properties under static and dynamic loads were measured at 293 K and 4 K. Phase analysis in a DRON-2.0 x-ray diffractometer revealed a pure austenite in all steels with up to 10% Al, no phase transformation occurring during plastic deformation and cooling to 4 K. While the magnetic permeability of all these austenitic steels is the same and not temperature dependent, the mechanical properties improve with increasing aluminum content and those of 90Mn30Al10 are best for cryogenic applications. As the aluminum content exceeds 10%, ferrite (α -phase) forms and reaches 5-7% in 90Mn30Al11 steel (10.85% Al) with the magnetic permeability increasing correspondingly and some mechanical properties worsening somewhat. Fractographic analysis revealed pitting as the principal fracture mechanism in the austenitic steels, with quasi-brittleness building up peripherally, and spallation as the fracture mechanism in the 90Mn30Al11 steel at 4 K. Magnetic transformations during cooling tend to keep the magnetic permeability constant, but grain reorientation from $\{110\} <001>$ to $\{110\} <112>$ caused by plastic deformation up to 40% results in an anomalous decrease of magnetic permeability and electrical resistivity.

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UDC 668.15'26'71:539.67:661.665

SOLUBILITY OF TiC AND Nb₄C₃ IN HIGH-CHROMIUM FERRITE

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian
No 4, Apr 86 pp 38-40

[Article by N.A. Gorokhova, V.I. Sarrak and S.O. Suvorova, Central Scientific Research Institute of Ferrous Metallurgy imeni I.P. Bardin]

[Abstract] The solubility of refractory carbides TiC and Nb₄C₃ in high-chromium ferrite of five 15% Cr+ 5% Al high-temperature steels was measured for determination of the detrimental carbon content. Specimens of all steels (1. 0.03% C; 2. 0.06% C, 0.40% Ti; 3. 0.03% C, 0.28% Ti; 4. 0.04% C, 0.73% Nb; 5. 0.03% C, 0.36% Ti+ 0.24% Nb) were quenched first from 1250°C in water after 1 h, for equalization of their grain sizes, and then again from various temperatures in 100°C steps for determination of the temperature dependence of carbide solubility over the 1350-550°C range. Measurements were made by the method of internal friction and its temperature dependence, with an "inverted" torsion pendulum oscillating at a frequency of 1 Hz as relaxator and with wires 0.8 mm in diameter as specimens. The internal friction was found to reach its maximum within the 260-280°C range, the magnitude of this Snoek peak being proportional to the carbon content in the solid solution and not depending on the nitrogen content (nearly all the nitrogen being combined into aluminum nitride and titanium or niobium carbonitride). Analysis of the results and calculations have

yielded the logarithm of the solubility product as a function of the temperature, in the form

$$\log L_{[Ti][C],[Nb][C]} = -\frac{a}{T} + b \quad (a = 8250 \text{ and}$$

$b = 4.11$ for TiC in steel with 0.06% C, $a = 9500$ and $b = 3.74$ for Nb_4C_3 in steel with 0.03% C). Addition of titanium or niobium to such a steel thus decreases the solubility of carbon in it, Nb_4C being a more stable carbide than TiC at 1150-1350°C temperatures. References 8: 5 Russian, 3 Western (1 in Russian translation).

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CSO: 1842/195

UDC 669.15-194:539.52:548.7

MAGNETIC TRANSFORMATION IN Cr15Mn16Ni2Al2 CHROMIUM-MANGANESE STEEL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 4, Apr 86 pp 40-42

[Article by O.A. Bannykh, P.Ye. Merinov, O.B. Chulanov and S.D. Entin, Metallurgy Institute imeni A.A. Baykov and Central Scientific Research Institute of Machine Building Technology Scientific-Production Association]

[Abstract] Phase transformations in Cr15Mn16Ni2Al2 steel (15.1% Cr, 16.2% Mn, 2.4% Ni, 2.4% Al, 1.2% Si, 0.27% Mo) during heating and during cooling are analyzed on the basis of thermomagnetic theory and measurements made with the TMA-2 instrument built at the Central Scientific Research Institute of Machine Building Technology. Specimens of this steel were thermomechanically treated in two modes: 1. annealing at 1250°C (metastable δ -ferrite phase) + rolling to 70% reduction at 1250°C + water cooling; 2. quenching from 1250°C + rolling to 70% reduction at 450°C ($\delta \rightarrow \gamma$ transformation) after holding at 850°C for 15 min. The temperature dependence of the magnetic susceptibility was measured during heating to 1100°C and then cooling at a rate of 300 K/h with a 40 min holding period at 850°C as well as during heating to 1250°C and then cooling at a rate of 1200 K/h with a 40 min holding period at 900°C. The resulting thermomagnetic curves reveal that the Curie point is near 480°C, the cooling curves being steeper than the heating curves and indicating transition of the paramagnetic δ -ferrite to the antiferromagnetic ordered state. Steel with a $\delta+\gamma$ structure in the initial state is characterized by magnetic transformation and, therefore, a smaller difference between heating and cooling curves of the magnetic susceptibility than the appreciable difference between those curves for steel with a δ -structure in the initial state. Either thermo-mechanical treatment of the steel in a paramagnetic initial state anomalously lowers the temperature at which $\delta \rightarrow \gamma$ transformation begins and raises the rate at which it proceeds. References 3 (Russian).

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NONFERROUS METALS AND ALLOYS: BRAZES AND SOLDERS

NEW NONFERROUS METAL PROCESS DEVELOPED

Moscow MOSKOVSKAYA PRAVDA in Russian 30 Mar 86 p 3

[Article by N. Lazareva: "A Compact Unit"]

[Text] A new processing method for obtaining nonferrous metals will yield an economic effect worth tens of millions of rubles as compared with traditional methods.

Silver cobalt with a color play of rose and bluish gray lead, red copper and gleaming white tin--not a single sector of the national economy can do without items made from these nonferrous metals. They are needed to create nuclear reactors and dishes, magnets and cutting tools, refrigerator parts and ornaments, storage batteries and sculptures, complex plant apparatus and micro-fertilizers.

This list could be continued without any difficulty, for after all, man began to use nonferrous metals as early as ancient times. For example, copper is among the first metals that people learned to recover from oxygen compounds contained in ores. Using coal they lighted huge bonfires and blew air through pipes and a bellows. The fires were encircled by walls and were gradually increased in height--the first shaft furnace was created in this way.

Clearly, each century, and sometimes even decade, has introduced its own substantial correction to methods of obtaining nonferrous metals. If one takes nonferrous metallurgy today, all the smelting processes can be divided into two categories. One is the traditional, using coke, gas and electrical power. The other group includes the so-called autogenic processes, in which customary fuel is no longer required--it is replaced by oxygen. In the last two decades the mining-metallurgical combines in the country have an undoubted preference for furnaces operating by using oxygen, which leads to a sharp reduction in energy input. Also belonging to this category is the method developed by specialists from the Moscow Institute of Steel and Alloys under the direction of Professor A.V. Vanyukov. Smelting in a liquid bath, however, is a qualitatively new and technological decision and technical equipment "make-up."

Valentin Semenovich Tsesarskiy, section director of the Department of Heavy Nonferrous Metals at MISiS [Moscow Order of the Red Banner Institute of Steel and Alloys], worked out at his desk the sketch of a new unit. The furnace occupies a small area--36 square meters. In the sketch it looks like an extended rectangle. Along the sides are siphons through which slags and an intermediate product, matte-alloy of sulfides, in which the metal is concentrated, are continuously drawn off from the furnace.

"This quite important detail should be noted," says Valentin Semenovich. "Our industrial process, as distinct from the existing ones, permits a much greater degree of moisture in the concentrates, and this already represents a considerable saving at the drier. The mixture need not be reduced to a pulverized state, as it is sufficient to break it up into small lumps."

It is not by chance that the new method obtained the name--smelting in a liquid bath. In reality, within the furnace the entire mass is in a smelted state. The oxygen-air mixture enters from the side under high pressure. The oxidation process is accompanied by high heat release and therefore the necessary temperature is always maintained inside the melt. Then, because of the difference in the specific gravity, the slag and matte, in which the nonferrous metal content is much higher than usual, are easily separated. This compact unit, by its own productivity, can replace 10 traditional furnaces of the same area.

The matte comes from the furnace into converters, where the oxidation process is completed. The new unit, however, seemingly takes on itself fulfillment of part of this operation, for after all rich metal matte is already obtained here. Specialists are now working on combining these two processes. The high degree of mechanization and automation, which considerably facilitates the work of the metallurgists, should also be noted among the advantages of the new industrial processes.

The development of an all-union program specifying the conversion, in the 12th Five-Year Plan, of several of the country's major mining-metallurgical combines to the new industrial process has been completed. The work of the first three experimental-industrial units at Norilsk and Balkhash has shown the promise and economy of the new device. Smelting in a liquid bath has been of interest to many countries which have applied to acquire the license.

The new industrial process gives a graphic idea of nonferrous metallurgy today and tomorrow.

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PHASE STRESSES IN EMBRITTLEMENT OF INGOTS OF HIGHLY ALLOYED MOLYBDENUM

Moscow FIZIKA I KHMIMIYA OBRABOTKI METALLOV in Russian No 1, Jan-Feb 86
(manuscript received 11 Apr 83) pp 135-139

[Article by S.I. Yudkovskiy, V.K. Ivanov, Yu.S. Popova and S.K. Akifyev,
Moscow]

[Abstract] The significance of phase stresses in the process of crack formation in ingots of Mo-Ti-C high alloys is studied. Internal stresses developing in the matrix at the interface with particles due to differences in coefficients of linear expansion are calculated. The high stresses, which develop primarily due to coagulation of particles of titanium carbide in the Mo-Ti-C eutectic, can be relaxed by formation of cracks in the ingot or by plastic deformation, i.e., generation of dislocations. The dislocation density generated by particles of the second phase during separation and coagulation is estimated to determine the capability of the unalloyed molybdenum and the alloy with 30 vol.% titanium carbide in the eutectic to relax phase stresses by plastic deformation. It is found that the total dislocation density which must be achieved to relax the phase hardening in the alloy with 6% titanium carbide is four orders of magnitude higher than in unalloyed molybdenum. References 8: 5 Russian, 3 Western.

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EFFECT OF Sc, La, Sm ON OXIDATION OF ALUMINUM

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 15 May 84) pp 241-244

[Article by V.G. Shevchenko, V.I. Konopenko, I.A. Neuymina, V.A. Kochedykov, and L.A. Akashev, Chemistry Institute, Ural Scientific Center, USSR Academy of Sciences]

[Abstract] Alloying aluminum with rare-earth elements has been found to improve the physical and mechanical characteristics required for powder metallurgy, but the oxidation characteristics are also an important factor in the search of new and better alloys. In an experimental study related to this problem, powder and compact specimens of 99.9% pure aluminum (grade AV-000), scandium (grade SkI-2), lanthanum (grade LaI-3), samarium (grade SmI-2) as well as of binary aluminum alloys with 0.1 atom.% and with 1.5 atom.% of each of these three elements were tested for high-temperature oxidation in air during heating at a rate of 7.5°C/min up to 1673 K. The alloys had been produced in a vacuum furnace at temperatures approximately 50 K above the respective liquidus line. Measurements were made by three independent methods. Powder specimens for thermogravimetry with an MOM (Hungarian) derivatometer were produced by crushing and passing through a sieve of 63 μm mesh size. Compact specimens in the form of plane-parallel plates for ellipsometry with an LCF-3M instrument using a BESM-6 high speed computer and for infrared spectroscopy with a Specord 75 IR spectrophotometer had carefully polished and cleaned surfaces. Protective oxide films formed on Al and Sc immediately after measurements, 70 Å and 50 Å thick respectively. The protective film on Sm was 300 Å thick, but the protective oxide film on La continued growing beyond 24 h into an optically absorbing and therefore nonhomogeneous one. The results pertaining to aluminum alone and each of the rare-earth elements agree with available data. The results pertaining to the alloys agree generally with the theory of heat-resistant alloying, but the differences in composition between surface layer and bulk material do not fit any known theory of oxidation. It can only be concluded that rare-earth element, in small amounts, influence the kinetics of aluminum oxidation and that an aluminum alloy with a more oxidizable element will be more penetratively transformed. References 9: 7 Russian, 2 Western (both in Russian translation).

2415/9835
CSO: 1842/174

UDC 669.295

COMMINUTION AND SIEVE ANALYSIS OF Ti-SPONGE POWDER

Moscow TSVETNYYE METALLY in Russian No 3, Mar 86 pp 55-56

[Article by I.A. Shulyak, A.P. Archakov, Yu.A. Snetkov, V.M. Prozorov and V.A. Drozdenko]

[Abstract] A comparative sieve analysis of Ti-sponge powder in conjunction with a time study of the comminution process in a drum (ball mill) crusher and in a vibrator crusher reveals a much superior performance of the latter. Although the crushing time in a drum rotating typically at 30 rpm with 300 kg of steel balls for 100 kg of sponge powder can be reduced by prior pressure treatment, to decrease the mean grain size of the charge, and the productivity of a drum can be increased by conversion from the present periodic action to more easily mechanized and automated continuous action, crushing in a vibrator of typically 10 dm³ capacity will produce 52-81% more of the required grain size fractions within the same time and the productivity of a vibrator is still approximately five times higher. The gist of this advantage is the absence of kinematic constraints, which exist in a ball mill, on increasing the energy of individual collisions for intensification of the crushing process. The ultimate criterion, however, will have to be performance of both types of crusher within the total industrial production cycle. References 2 (Russian).

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CSO: 1842/180

UDC 669.018.25:622.24

QUALITY OF HARD ALLOYS FOR ROCK AND WELL DRILLING TOOL

Moscow TSVETNYYE METALLY in Russian No 3, Mar 86 pp 107-110

[Article by N.P. Krayev]

[Abstract] Since the cost of hard-alloy tools ranges from 15% to 40% of the total rock or well drilling cost, quantitative relations between technical and economic characteristics of the drilling operation need to be established for optimization of the machine and tool system. This is done for tools made of VK6V, VK8V, VK11V, VK15 V-Co alloys. Tool performance and cost analysis is based on the dependence of tool life on machine power. The total unit cost of a drilling operation, cost per meter of excavation and cost per tool bit, is calculated each way as a function of the machine power rating for various values of the tool quality or operating stability indicator. There is a minimum unit cost at some machine power rating in each case so that the economically optimum tool quality can be determined from these relations. The number of tool bits necessary for a drilling

operation is calculated on the basis of technical criteria including tool production and tool application. If the optimum tool quality indicator corresponds to a minimum cost of a drilling operation not equal to the actual drilling cost, then scientific and engineering effort is required to improve the machine-tool-rock interaction. References 4 (Russian).

2415/9835

CSO: 1842/180

NONMETALLIC MATERIALS

DIAMOND-HARD MATERIAL CREATED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 3 Apr 86 p 2

[Article by V. Vladimirov: "Miracle-Diamond"]

[Text] The new super-hard material, "SKM-R", not inferior in hardness to the natural diamond, has been created at the Poltava Plant for Synthetic Diamonds and Diamond Instruments imeni 50-letiye SSSR. Cutting tools and knives for presses equipped with it have a life dozens of times longer than a hard alloy tool, and are suitable for machining high-impact alloys of nonferrous metals, ceramics and plastic. Use of the innovation ensures a 3-5-fold increase in labor productivity and high precision and smoothness of the surface and will yield an annual effect of over 500,000 rubles. Poltava workers developed the output of the new tool by using existing equipment.

12151
CSO: 1842/191

UDC 621.791.72:621.373.826

ENERGY CHARACTERISTICS OF CUTTING LAMINATE PLASTICS WITH CONTINUOUS-WAVE
 CO_2 -LASER BEAM

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 1, Jan 86 pp 32-34

[Article by A.G. Grigoryants, doctor of technical sciences, and A.A. Sokolov, candidate of technical sciences, Moscow Higher Technical School imeni N.E. Bauman]

[Abstract] The power relations which characterize the process of cutting laminated plastics with a continuous-wave CO_2 -laser beam are analyzed, considering the relatively low power density of only 10^3 - 10^4 W/cm², precluding thermal breakdown of the material, as well as the wide range of energy required for cutting: from very low for cutting acrylic glass to very high for cutting textolite. The power balance includes the plasma and the aerosol, only the latter justifiably assumed to attenuate the laser radiation by absorption and scattering in accordance with Bouguer's law. Simple expressions are derived for process performance evaluation which are easily verifiable experimentally by the method of laser probing. References 5: 4 Russian, 1 Western (in Russian translation).

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UDC 661.862.001.5

FURTHER RESEARCH ON THE SYNTHESIS OF ALUMINUM TITANATE

Moscow OGNEUPORY in Russian No 1, Jan 86 pp 21-23

[Article by V.P. Tarasovskiy, Ye.S. Lukin and N.A. Popova, Moscow Chemical Technology Institute imeni D.I. Mendeleyev]

[Abstract] The synthesis of aluminum titanate in the temperature range of 1000-1600°C was studied by various methods. Aluminum titanate powder with

isometric particles less than 1 micrometer was chemically precipitated from highly pure components. Differential thermal analysis of the stoichiometric mixture of hydroxides in the 20-1500°C interval, performed on a "System F. Paulik, G. Paulik, L. Erdey" device, showed that the water of crystallization was expelled between 100-250°C, the crystallization of Al_2O_3 and TiO_2 occurred between 940-1020°C, and the formation of aluminum titanate occurred between 1380-1440°C. An aluminum titanate powder standard was prepared by calcinating the mixture at 1600°C for 3 hours. Petrographic analysis revealed that an intermediate phase resembling neither aluminum or titanate oxides of aluminum titanate is formed at 1250°C and that aluminum titanate was obtained at 1400°C. As the temperature was increased to 1500°C, the crystals increased in size and acquired a prismatic shape. X-ray phase analysis on a DRON-2 indicated the formation of aluminum titanate powder at 1400°C. Infrared spectral analysis using a UR-10 device corroborated the other analyses.

13050/9835
CSO: 1842/149

UDC 666.762.5.032.4

A STUDY OF THE SLIP-CASTING OF CERAMICS BASED ON CHEMICALLY CO-PRECIPITATED STABILIZED ZrO_2

Moscow OGNEUPORY in Russian No 1, Jan 86 pp 24-28

[Article by Yu.Ye. Pivinskiy, A.A. Dabizha, V.I. Ulrich, N.D. Buravova, L.P. Ivanova and Ye.A. Chukhustova]

[Abstract] The effect of different heat-treatment temperatures, solid-phase dispersion, suspension concentration, and suspension pH on the rheological properties of aqueous suspensions of ZrO_2 and on certain physical properties of castings and sintered material made from zirconia was investigated. The zirconia was chemically co-precipitated from salt solutions and stabilized with 15.5% Y_2O_3 (yttrium oxide). This material was heat treated at 1000° to 1500°C and then pulverized in a corundum-lined pulverizer. Heat treatment at 1000° to 1100°C increased the pulverization rate and the suspension pH. Heat treatment at 1500°C had the opposite effect. An inverse relationship existed between particle size and the pulverization rate. The concentration of yttrium oxide in the base material significantly affected the porosity, drying shrinkage, and calcination losses of the castings. Suspension pH was increased through pulverization. The porosity of the castings increased as the pH level rose. The strength of the castings varied inversely with the pH level of the suspension. Sintered material made from powder heat-treated at a higher temperature had greater strength. Higher dispersity of the powder particles lowered the porosity and increased the mechanical strength of the castings and sintered material. Higher values for C_v (volumetric fraction of the solid phase) resulted in lower porosity and greater strength in the castings and sintered material. Higher heat-treatment temperatures for the powder were associated with higher C_v values

and greater strength in the ceramics made from this powder. References 17: 14 Russian, 3 Western.

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CSO: 1842/149

UDC 666.593.017:539.4

INVESTIGATING THE "AGING" PROCESS OF QUARTZ CERAMICS

Moscow OGNEUPORY in Russian No 1, Jan 86 pp 28-32

[Article by Ye.I. Syzdaltsev]

[Abstract] Quartz ceramic blanks slip cast in gypsum molds were fired in electric furnaces at 1150°, 1250°, and 1300°C to produce three batches of varying density. These specimens then underwent additional heat treatment at temperatures ranging from 900° to 1350°C, increased in increments of 25° to 50°C. Heat treatment lasted from 10 to 100 hours. The density, transverse (bending) strength, dielectric permittivity, static elasticity modulus, and linear thermal expansion coefficient were studied. The higher the initial firing temperature, the higher the density of the original specimens. The denser specimens began to sinter at lower temperatures and consolidated faster. As the temperature and duration of additional heat treatment were increased, the material quickly lost its strength due to crystallization. The existence of the crystalline phase was determined using an MIM-7 microscope. An attempt to determine the relationship between the crystalline phase and density using an URS 50IM X-ray machine was unsuccessful. Each batch completely lost its strength within a certain phase of the heat-treatment process. The elasticity modulus and the permittivity increased as density increased during additional heat treatment. Neither property was affected by the structural changes occurring as a result of heat treatment. The linear thermal expansion coefficient rose in conjunction with the extent of the crystalline phase. References 3 (Russian).

13050/9835
CSO: 1842/149

USING STANDARD-REFERENCED CONTACT POROMETRY TO STUDY THE PORE STRUCTURE OF REACTION-SINTERED SILICON NITRIDE

Moscow OGNEUPORY in Russian No 1, Jan 86 pp 32-35

[Article by I.Ya. Guzman, Ye.B. Bendovskiy, K. Khints and Ye.A. Anikin, Moscow Chemical Technology Institute imeni D.I. Mendeleyev]

[Abstract] Standard-referenced contact porometry was used to study the pore structure of silicon nitride ceramics. Pore distribution according to size was determined first for unfired compacted blanks containing finely pulverized silicon and silicon with large grains of SiC or Al_2O_3 . These blanks were then subjected to reaction sintering in a nitrogen medium at $1350^{\circ}C$ for 15, 30, 120, and 240 minutes. The change in total porosity and pore size were measured with standard-referenced contact porometry. Decane was used as the working fluid. The porosity of the ceramics gradually decreased over the time of nitrogen sintering. The rate of decrease also fell over time. During the initial time stages, porosity decreased due to the reduction in the size of the large pores and the growing together of the small pores. Later, porosity was reduced as the predominantly sized pores overgrew. Two types of pores were identified in specimens containing the finely pulverized silicon and the large grains of SiC. References 2 (Russian).

13050/9835
CSO: 1842/149

POSSIBILITY OF DEEP DOPING OF SEMICONDUCTOR PLATES BY REMELTING THE SURFACE LAYER WITH A CONCENTRATED LIGHT BEAM WITH SIMULTANEOUS BODY HEATING

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 1 Jan-Feb 86
(manuscript received 14 Jun 84) pp 25-29

[Article by D.M. Gureyev and A.I. Lendyayev, Kuybyshev]

[Abstract] A powerful laser beam can be used to create diode structures in semiconductors with inverse conductivity at room temperature. The maximum concentration of impurities is located near the irradiated surface. This article studies diode structures produced by this method at higher temperatures. Calculated and experimental data agree well when the method of finite differences is used as the basis of the calculation. The method allows qualitatively correct description of the experimental results, thus expanding the capabilities for using this method for the creation of power semiconductors. References 10: 5 Russian, 5 Western (4 in Russian translation).

6508/9835
CSO: 1842/186

UDC: 539.234:548.5:621.375.826

CRYSTALLIZATION OF DROPLETS TRANSFERRED FROM A TARGET HEATED BY LASER RADIATION ON A SINGLE CRYSTAL SUBSTRATE

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 1, Jan-Feb 86
(manuscript received 12 Dec 84) pp 30-33

[Article by P.D. Kervalishvili, E.R. Kuteliya, N.A. Golodze and O.G. Dzmitseishvili, Tbilisi]

[Abstract] The purpose of this work was to study the process of transfer of melt droplets to a single crystal substrate and to investigate the nature of their crystallization. The evaporated substances used were boron and germanium. The substrates were single crystal specimens of sapphire and silicon. Experiments were performed in a vacuum of at least $1 \cdot 10^{-6}$ Pa with varying distances between the target and substrate. A pulse mode solid neodymium laser served as the energy source, yielding pulses of about 1 J energy, pulse length of 30 μ s and pulse repetition frequency of 20 per minute. The experiments demonstrated that, under these conditions with a laser beam diameter of about 1 mm, melt droplets are ejected and transported to the surface of the single crystal substrate, where they crystallize rapidly into single crystals of both germanium and boron, in spite of the wide difference in the crystallization temperatures of the two substances.

References 8: 3 Russian, 5 Western (3 in Russian translation).

6508/9835
CSO: 1842/186

UDC 669.3'74'24:538.26

MAGNETORESISTANCE OF Cu-Mn AND Cu-Mn-Ni SPIN GLASSES IN STRONG MAGNETIC FIELDS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 61, No 2, Feb 86 (manuscript received 21 Dec 84, in final version 15 Apr 85)
pp 284-288

[Article by V.M. Beylin, L.A. Serebrenik, M.V. Rashkovskiy and S.V. Demishev, State Scientific Research and Planning Institute of Alloys and Nonferrous Metals Processing]

[Abstract] In an experimental study of spin glasses the magnetoresistance of Cu-Mn alloys with 2-25 atom.% Mn and correspondingly different freezing points as well as different structures was measured in magnetic fields up to 14 T or $1.1 \cdot 10^7$ A/m strong. Electrical resistance measurements were made by the 4-point method accurately within 5%, on wire specimens 0.2 mm in diameter which had been annealed in vacuum at 700°C for 1 h and then quenched in water from 750°C. The freezing point was determined from the

temperature dependence of the dynamic magnetic susceptibility in a magnetic field of $2.4 \cdot 10^3$ A/m intensity, this dependence being based on measurements by the induction method inside a solenoid with signals from an audio-frequency oscillator and having been recorded with an XY-plotter. A non-magnetic impurity, namely 2-11 atom.% Ni ions, was added for a determination of its effect on the magnetoresistance of those alloys. An analysis of the results, assuming a canonical statistical distribution of spin configurations (S_1^{\pm}, S_2^{\pm}) in the Mn-Mn pair with $S = 3/2$, indicates that the magnetoresistance of alloys with 5-25 atom.% Mn and 2-11 atom.% Ni is negative at temperatures above 4.2 K but that its magnitude decreases especially with increasing Ni content c_{Ni} and also with increasing Mn content c_{Mn} . The data do not fit the model of a $\delta\rho/\rho_0 = K H^n$ field dependence of the relative change in electrical resistivity (K- constant, $n = 2$ for $H < 4.8 \cdot 10^6$ A/m and $n < 2$ for $H > 6.4 \cdot 10^6$ A/m), according to the Mookerjee-Chowdhury theory, but fit a linearizable logarithmic dependence of $\delta\rho/\rho_0$ on c_{Mn} and c_{Ni} with an also logarithmic dependence of $H_{res} - H_{ext}$ on H_{ext} (H_{res} - resultant magnetic field, H_{ext} - external magnetic field). The magnetoresistance of these alloys was found to be sensitive to their magnetic history and, accordingly, subject to hysteresis within the range of low magnetic field intensity. The readings of electrical resistance depended on the manner in which the wire specimens had been connected to the potential terminals of the measuring instrument, an additional negative magnetoresistance appearing in the case of a soldered joint made with POS-40 solder and disappearing in the case of a spot-welded joint. References 11: 1 Russian, 10 Western.

2415/9835
CSO: 1842/167

UDC 669.862'25:539.216.2:539.213

THERMOMAGNETIC TREATMENT OF AMORPHOUS Gd-Co FILMS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 61, No 2, Feb 86 (manuscript received 22 May 85) pp 406-407

[Article by G.S. Kandaurova, V.V. Lesnykh, V.O. Vaskovskiy and Ye.M. Tokareva, Ural State University imeni A.M. Gorkiy]

[Abstract] Thermomagnetic treatment of amorphous $Gd_{0.18}Co_{0.82}$ films was studied, for the purpose of determining its effect on the perpendicular magnetic anisotropy in them. Specimens of such films approximately 1 μm thick were produced by high-frequency ion sputtering and deposited on glass substrates with water cooling. They were then coated with glass for maximum shielding against oxidation in aggressive media, their chemical stability being further increased by annealing. Pairs of specimens were treated thermomagnetically in a helium atmosphere for 1 h, namely they were annealed at successively higher temperatures in a magnetic field of 1.36 MA/m intensity perpendicular to the plane of one specimen and parallel to the plane of the other. As the annealing temperature was raised above 80°C, the axis of easy

magnetization changed into a cone of easy magnetization with a successively wider angle and finally into a plane of easy magnetization after annealing at temperatures above 400°C. The compensation temperature of these films dropped correspondingly from 207 K to 187 K. Films annealed in a magnetic field parallel to their plane were found to retain their perpendicular anisotropy and to acquire an additional one with the axis in the direction of the magnetic field, their labyrinth structure changing to domain bands with walls parallel to the magnetic field. The temperature dependence of the anisotropy constant K_A indicates that this constant does not depend on the orientation of the magnetic field and of the magnetization vector during annealing. The temperature dependence of the anisotropy constant K_H indicates saturation by annealing at 200°C in a magnetic field. This constant was found to decrease fast during subsequent annealing and holding at 200°C without a magnetic field. References 6: 2 Russian, 4 Western.

2415/9835

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UDC 546.28

EFFECT OF GADOLINUM DOPANT ON ELECTRICAL AND OPTICAL PROPERTIES OF SHAPED SILICON CRYSTALS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 22 May 84) pp 181-185

[Article by N.V. Abrosimov, V.N. Abrosimova, A.V. Bazhenov and S.A. Yerofeyeva, Solid State Physics Institute, USSR Academy of Sciences]

[Abstract] Shaped silicon crystals would be excellent for use as active elements in solar cells operating on the ground and as structural elements in microelectronic devices if the residual impurity concentration acquired through contact of molten silicon with the graphite forming tool were not high. Elements of the rare-earth group added to the silicon melt in the Czochralski process lower the concentration of certain impurities through reaction with them and precipitation of the products from the solidifying crystal. A study of this effect in the Stepanov process was made, considering the faster rate of crystal growth as well as the buildup of SiC inclusions and boundary layers owing to intimate silicon-graphite contact. Hexahedral prisms with 20 mm long base edges and 0.4 mm high lateral edges were grown at a pulling rate of 20 mm/min. The same shaper made of MPG-6 graphite was used for batches of plain p-Si crystals and Si+Gd crystals. Original crystals prior to doping had a concentration of free charge carriers $p = 2 \cdot 10^{16} \text{ cm}^{-3}$ with a mobility $\mu = 243 \text{ cm}^2/(\text{V} \cdot \text{s})$ at 300 K. These two electrophysical properties and their temperature dependence were measured at four doping levels which covered the 0.05-1.5 wt.% Gd range, including transition to n-type conductivity and return to p-type conductivity. Optical measurements involved analysis of the infrared transmission spectrum

with a Specord 75 IR 2-beam spectrometer, concentrations of optically active oxygen and carbon being particularly important indicators. The ultimate purpose was to establish the effect of doping on Fe and Ti concentrations in such doped Si crystals, these two impurities being the principal producers of deep electron states within the forbidden band and of recombination centers for minority carriers. Their concentrations were measured by the method of laser-emission spectral analysis, by photometering the negatives of spectrograms, and under an MS-46 electron microscope. The results reveal a drop of Fe and Ti concentrations in the crystal with rising Gd concentration in the melt. The rare-earth dopant has been found to precipitate into the residue of Si melt in the crucible and to pull impurities along. The authors thank N.G. Martynenko for making measurements by the Hall-emf method, A.V. Fadeev for assistance in processing the infrared transmission spectra and S.A. Shevchenko and N.T. Bagrayev for helpful discussion of the results. References 10: 6 Russian, 4 Western.

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UDC 539.293:54

ETCHING EDGE-EFFECT AND ITS USE IN FABRICATION OF MICROLENSES

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 31 May 84) pp 191-194

[Article by L.N. Vozmilova and V.G. Malyarova]

[Abstract] The etching edge-effect is undesirable in fabrication of contact windows and mesa structures, especially for thin epitaxial layers, but is useful in fabrication of monolithic microlenses for light-emitting diodes on Gal_xAl_xAs structures. While its mechanism is not yet understood, various factors influencing its magnitude have been determined in a study aimed at optimization of the etching process. Experiments were performed on GaAs specimens with (100)-orientation. After masking with a SiO_2 film and cutting tracks in the latter, according to the photolithographic process sequence, etching was done at room temperature with an isotropic aqueous bromine solution, without stirring, at a rate limited by diffusion only. The effect of stirring was determined in a separate experiment with equipment used for dynamic chemical polishing. The etching depth along the centerline of a track was measured under an MIS-11 microscope accurately within $\pm 0.27 \mu m$ and the edge-effect height was measured with an MII-4 microinterferometer accurately within $\pm 0.03 \mu m$. The maximum edge-effect height was found to increase with increasing track width, while the etching depth was found to be proportional to the etching time but to decrease with increasing channel width. As the mask strip between two tracks was widened, both etching depth and edge-effect height increased first fast and eventually much slower. A neighboring mask strip was also found to influence both etching depth and edge-effect height by decreasing them, especially a very narrow

one with another track on the other side. Accordingly, the maximum edge-effect height will correspond to a certain etching depth in GaAs for any given channel width. Considering that hydrodynamic processes in the channel most likely determine the magnitude of the edge effect, it is possible to optimize the etching process for fabrication of microlenses on the basis of these experimental results and geometrical analysis. References 3: 1 Russian, 2 Western.

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POLYCRYSTALLINE ZnSe

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 7 Jun 84) pp 208-210

[Article by M.N. Vladko, V.I. Dernovskiy and V.A. Tatarchenko, Solid State Physics Institute, USSR Academy of Sciences]

[Abstract] Production of polycrystalline ZnSe by chemical deposition from the vapor phase is analyzed for the purpose of process optimization with respect to purity and optical quality of the product as well as maximum yield under most favorable technological conditions. The excellent properties of this material make it very suitable for components of infrared power lasers. The most favorable ZnSe producing chemical reaction is $Zn(vapor) + H_2Se(vapor) \rightarrow ZnSe(solid) + H_2(gas)$. It proceeds without precipitation of a second phase (Zn or Se) and resulting instability, which characterize the low-temperature reactions involving an organozinc compound and hydrogen sulfide or organozinc and organoselenium compounds. It also proceeds without the danger of halogen inclusions appearing in the product, which characterizes reactions involving a zinc halogenide and hydrogen sulfide. An experimental optimization study of chemical deposition on the basis of this reaction was made, using chemically pure metallic zinc and H₂Se produced by synthesis of the two component elements. Solid zinc was vaporized from a graphite crucible and zinc vapor was carried by a stream of diluting inert gas through a cooling zone into a rectangular channel 300 mm long and 70x40 mm² in cross-section, made of SU-2000 glass-carbon composite, for deposition on the inside walls. Both the crucible and the substrate channel had been placed inside a cylindrical quartz retort 1200 mm long and 105 mm in diameter with two independent heaters for controlling the vaporization rate and the deposition temperature respectively. The quality of polycrystalline ZnSe deposits was determined on the basis of optical measurements made after they had been removed from the substrate walls, cut, and polished with diamond powder. The process parameters were varied and 3-5 mm thick polycrystalline ZnSe plates as large as 65x150 mm² were produced under optimum conditions within the 650-800°C temperature range and the 2.7-18.6 kPa pressure range. The optimum flow rate of carrier gas was approximately 250 dm³/h, sufficiently

high to ensure a most nearly uniform deposit thickness with a taper not larger than 12% and sufficiently low for the reagents not to be carried beyond the deposition zone with a resulting decrease of the ZnSe yield. The polycrystalline ZnSe thus produced at deposition rates within 0.04-0.1 mm/h was of the 70-300 μ m grain size fraction with a total impurity content not exceeding 10^{-4} wt.%, and had an absorption coefficient of $2 \cdot 10^{-3}$ cm $^{-1}$ at the 10.6 μ m wavelength. The authors thank N.P. Kulakov for assistance in the optical measurements. References 14: 4 Russian, 10 Western.

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UDC 546.49'24+546.815

INTERACTION OF HgTe AND Pb

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 29 May 84) pp 224-227

[Article by V.N. Tomashik, P.F. Vengel, I.B. Mizetskaya and K.R. Kurbanov, Semiconductor Institute, UkrSSR Academy of Sciences]

[Abstract] An experimental study of processes occurring at the HgTe-(semiconductor)-Pb(metal) interface at temperatures up to 728°C on the liquidus line was made by the method of differential thermal analysis, using a microcalorimeter and an array of 64 chromel-alumel thermocouples. The microcalorimeter had been calibrated against the melting points of KNO₃, K₂SO₄ and Sb; graphite filling a quartz ampule served as reference standard. The temperatures were measured accurately within $\pm 3^\circ$ C. Several identical specimens of HgTe and Pb mixture with equivalent amounts of both and weighing 2 g each were heated to various temperatures, held there for various lengths of annealing time, then cooled. After that they were mechanically polished for microstructural examinations under an XM-7 microscope. Structure and composition of the transition layer forming at the HgTe surface during interaction with Pb at each temperature were determined on the basis of microhardness measurement and x-ray phase analysis. Thermodynamic analysis had already revealed that the chemical exchange reaction HgTe+Pb=HgTe+Pb occurs throughout the entire temperature range. The results of this study have revealed an endothermic effect at 327°C (melting point of Pb) and an exothermic effect at 551°C (completion of that reaction). References 4 (Russian).

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PROPERTIES OF PbTe-MnTe₂ ALLOYS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 25 May 84) pp 228-230

[Article by P.G. Rustamov, Ch.I. Abilov and S.G. Agdamskaya, Inorganic and Physical Chemistry Institute, AzSSR Academy of Sciences]

[Abstract] Interaction of PbTe and MnTe₂ during alloy formation was studied by the method of differential thermal analysis with an VTR-73 instrument using a Pt/Pt-Rh thermocouple and by microhardness measurement with a PMT-3 tester using a 0.1 N load. The constitution diagram was plotted, with the aid of x-ray phase analysis by the powder method in a DRON-2 diffractometer, not as that of a quasibinary system but as the PbTe-MnTe₂ section through that of the Pb-Mn-Te ternary system with terminal solid solutions in PbTe and peritectic MnTe+ liquid. MnTe₂+ α -phase transformation. Specimens of these alloys were produced by synthesis at approximately 1190 K in a vertical furnace without temperature gradient, interaction of manganese with the quartz retort having been prevented by graphitization of the latter, and subsequently homogenized by annealing at 573 K for 500 h. Their microstructure was examined under an MIM-7 microscope. The microhardness was found to increase from 450 MPa for PbTe to 570 MPa for 97 mol.% PbTe+ 3 mol.% MnTe₂, remain constant at this level throughout the binary range to 60 mol.% MnTe₂ (bright phase), and to rise to its 830 MPa level for MnTe₂ already at 75 mol.% MnTe₂ (dark phase). The temperature dependence of the electrical conductivity and the Seebeck coefficient was measured over the 300-900 K range for several alloys with up to 3 mol.% MnTe₂. The temperature dependence of electrical conductivity was found to be typical for semimetallic compounds. The temperature dependence of the Seebeck coefficient indicates saturation of the thermoelectric effect in the vicinity of 700 K at levels which increase with increasing MnTe₂ content. The energy gap, 0.3 eV for PbTe, was found to increase linearly with increasing MnTe₂ content.

References 6: 5 Russian, 1 Western.

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DEFECTS IN SYNTHETIC QUARTZ SINGLE CRYSTALS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 6 Jun 84) pp 245-250

[Article by M.N. Danchevskaya, O.G. Ovchinnikova and A.N. Tselebrovskiy,
Moscow State University imeni M.V. Lomonosov]

[Abstract] An experimental study of synthetic α -quartz single crystals was made by two methods, thermoluminescence and electron paramagnetic resonance, for a determination of their principal defects. In addition to "intrinsic" structural defects and structural defects in the form of interstitial Li^+ , Na^+ , Al^{3+} , and H_2O impurities, "growth" defects in the form of Al^{3+} , Li^+ , Na^+ and H^+ impurities and oxygen or silicon vacancies, irradiation of any kind produces "new" defects as a result of a redistribution of released charge carriers among the "growth" defects. These defects can be and have been detected by both methods. Specimens of synthetic α -quartz single crystals were gamma-irradiated from a Co^{60} -source with 8 Grad/s intensity at room temperature. Some were irradiated once to a full dose for measurement of EPR signals, which appeared only after irradiation to a dose of $5 \cdot 10^5$ Grad, and recording of their spectra. Some were irradiated repetitively with cumulative buildup of a dose and annealing after each irradiation at a successively higher temperature, up to 400°C , for establishing the temperature dependence of their thermoluminescence. The thermoluminescence was also measured after a single irradiation to the same total dose of repetitive irradiation. The low-temperature intensity peak at 90°C was slightly higher after repetitive irradiation with annealing in between than after single irradiation. The high-temperature intensity peak at 250°C , much lower than the low-temperature peak after single irradiation, was much higher than the low-temperature peak after repetitive irradiation with annealing in between. Both thermoluminescence and EPR data indicate the existence structural impurity defects and intrinsic vacancy defects responsible respectively for 0.9 ± 0.1 eV deep and 2.3 ± 0.2 eV deep electron traps produced by γ -radiation in α -quartz single crystals with low impurity content. References 20: 10 Russian, 10 Western.

2415/9835
CSO: 1842/174

NEW $\text{Bi}_2\text{AB}_2\text{O}_9$ BISMUTH COMPOUNDS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
 (manuscript received 14 May 84) pp 266-269

[Article by L.A. Shebanov, L.V. Korzunova, V.G. Osipyan and
 E.Zh. Freydenfeld, Latvian State University imeni P. Stuchka, Scientific
 Research Institute of Solid State Physics and Riga Polytechnic Institute]

[Abstract] Six new perovskitic laminate bismuth compounds in the $\text{Bi}_2\text{AB}_2\text{O}_9$ series ($n=2$) of the $\text{Bi}_2\text{A}_{n-1}\text{B}_n\text{O}_{3n+3}$ group have been produced by simultaneous heterovalent substitution of ions in both A and B sublattices of $\text{Bi}_3\text{TiNbO}_9$ or $\text{Bi}_3\text{TiTaO}_9$ with retention of the total charge in the perovskitic layer and of the dimensional relations between interchangeable ions. These compounds ($Z=4$) and their melting points are: $\text{Bi}_2\text{Na}_{1/6}\text{Bi}_{5/6}\text{Ti}_{2/3}\text{Nb}_{4/3}\text{O}_9$ (1170°C)

$\text{Bi}_2\text{Na}_{1/6}\text{Bi}_{5/6}\text{Ti}_{2/3}\text{Ta}_{4/3}\text{O}_9$ (1220°C)

$\text{Bi}_2\text{K}_{1/6}\text{Bi}_{5/6}\text{Ti}_{2/3}\text{Nb}_{4/3}\text{O}_9$ (1210°C)

$\text{Bi}_2\text{K}_{1/6}\text{Bi}_{5/6}\text{Ti}_{2/3}\text{Ta}_{4/3}\text{O}_9$ (1250°C)

$\text{Bi}_2\text{K}_{1/6}\text{Bi}_{5/6}\text{Ti}_{4/3}\text{W}_{2/3}\text{O}_9$ (1150°C)

$\text{Bi}_2\text{Pb}_{1/3}\text{Bi}_{2/3}\text{Ti}_{4/3}\text{W}_{2/3}\text{O}_9$ (1080°C)

For a study of their crystallographic and physico-chemical properties, polycrystalline ceramic specimens of these compounds, 1-3 mm thick and 15-17 mm in diameter, were produced by thermochemical reaction in the solid phase from fine-powder oxides or salts of the four metals. They were calcined first at 1000°C for 4 h and then, after repulverization, again at temperatures $30-70^\circ\text{C}$ below their melting points. Their phase composition was determined and crystal lattice parameters were measured in a DRON-2 x-ray diffractometer using a CuK_α -radiation source and nickel as β -radiation filter. The temperature dependence of their dielectric permittivity and loss tangent was measured at a frequency of 0.5 MHz over the $20-700^\circ\text{C}$ range, measurement at higher temperatures not having been possible because of increasing electrical conductivity. The field dependence of their dielectric polarizability was measured over the 0-30 kV/m range of electric field intensity at room temperature, hysteresis loops, even though far from saturation, having been recorded in the case of each compound. The data indicate that $\text{Bi}_2\text{Pb}_{1/3}\text{Bi}_{2/3}\text{Ti}_{4/3}\text{W}_{2/3}\text{O}_9$ is a ferroelectric material with the transition point at 580°C and the other five compounds are most likely also ferroelectric materials with transition temperatures above 700°C . References 5: 2 Russian, 3 Western.

2415/9835
 CSO: 1842/174

DEPENDENCE OF TEMPERATURE STABILITY OF RESONANCE FREQUENCY OF FERROELECTRIC PIEZOCERAMIC MATERIALS WITH PEROVSKITIC STRUCTURE ON INDIVIDUAL CHARACTERISTICS OF THEIR CONSTITUENT CATIONS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
 (manuscript received 29 May 84) pp 270-272

[Article by L.D. Grineva, S.V. Gavrilyachenko, A.Ya. Dantsiger and V.A. Ivanenko, Scientific Research Physics Institute, Rostov State University]

[Abstract] An experimental study of ferroelectric piezoceramic materials of the $PbTiO_3 - PbZnO_3 - PbB_{1-m}^{1-}B_m^{2-}O_3 - PbB_{1-n}^{3-}O_3 - PbB_n^{4-}O_3$ system with peroskitic structure was made, for the purpose of determining the dependence of the temperature stability of their resonance frequency on the electronegativity of their cations and thus on the chemical bond B - O or A - O in the perovskitic oxides. Four groups in this system were considered: with $B_{1-m}^{1-}B_m^{2-} = Sb_{2/3}Mn_{1/3}$ (first and second groups) or $W_{1/2}Mn_{1/2}$ (third and fourth groups), $B_{1-n}^{3-} = Nb_{2/3}$ (first and third groups) or $W_{1/2}$ (second and fourth groups), and $B_n^{4-} = Mg_{1/3}, Zn_{1/3}, Ni_{1/3}, Co_{1/3}, Mn_{1/3}$ (first group) or $Mn_{1/2}, Zn_{1/2}, Ni_{1/2}, Co_{1/2}$ (second and fourth groups) or $Mg_{1/3}, Zn_{1/3}, Ni_{1/3}, Mn_{1/3}$ (third group).

Specimens of each material were produced by hot pressing. The relative deviation from resonance frequency at $25 \pm 5^\circ C$ was measured by the standard method over the $-60 - (+85)^\circ C$ temperature range; the electronegativity was calculated in kJ/g-atom. The data reveal that the percentage frequency deviation decreases and the temperature stability of the resonance frequency accordingly increases with increasing electronegativity in the following order of B^4 cations: Mg, Zn, Ni, Co, In (first group), Mg, Ni, Zn, Co (second group), Mg, Zn, Ni, Mn (third group), Mg, Zn, Ni, Co (fourth group). The sequence of B^4 cations in increasing order of electronegativity is different in the second group than in the other three groups, owing to simultaneous presence of three variable-valence elements, Sb, Mn and W, in that group. The frequency deviation in the electronegativity range below 830 kJ/g-atom is much higher for first and third groups ($B^4 = Mg$, 700 kJ/g-atom), owing to the presence of Nb. The frequency deviation in the electronegativity range above 950 kJ/g-atom is lowest for the first group ($B^4 = Mn$, 1040 kJ/g-atom). While the trend of the frequency deviation (temperature stability) curves does not depend on the B^1 cation, the magnitude of the frequency deviation is larger and the temperature stability of the resonance frequency is accordingly lower with $B^1 = W$ than with $B^1 = Sb$. References 6 (Russian).

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GROWING H_2O SINGLE CRYSTALS BY FLOATING-ZONE METHOD UNDER CONDITIONS
SIMULATING WEIGHTLESSNESS

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 2, Feb 86
(manuscript received 14 May 84) pp 337-339

[Article by Sh. Mavlonov, Physical Technical Institute imeni S.U. Umarov,
TaSSR Academy of Sciences]

[Abstract] A scheme for growing single crystals by the floating-zone method under conditions simulating weightlessness is proposed, weightlessness being ensured by selecting a medium whose density is very close to that of the crystal material. For a demonstration of this scheme, single crystals of water (density 1.000 g/cm³ at 0°C) were grown in KhF-22 oil (density 0.996 g/cm³ at 0°C). Oil filled a tube in which water at a constant temperature of 2+0.1°C was circulated; an ice grain or a copper wire 1 mm in diameter held at one end of a horizontal rod served as seed and was cooled to -1+0.1°C or -2+0.1°C respectively by an aqueous solution of ethyl alcohol from a thermostat. The rod with the seed is spun about its horizontal axis by one RD-09 electric motor and simultaneously swept around the vertical axis by another RD-09 electric motor driving a vertical axle to which the rod has been coupled at the other end. The optimum speeds and their ratio are those which ensure equality of surface tension and centrifugal force on the growing crystal. The length of the rod and its sweeping speed must, moreover, be sufficiently large to avoid flooding of the seed by the melt (liquid water) but also sufficiently small to avoid separation of the melt (liquid water) from the seed and thus cessation of crystal growth. Regular cylindrical H_2O single crystals 7 mm long and 3 mm in diameter were grown experimentally with the 30 cm long rod spinning at 4 rps and sweeping at 2 rps. References 7: 4 Russian, 3 Western (all in Russian translation).

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WELDING OF PLASTIC TUBES UNDER PRESSURE GENERATED BY MAGNETIC PULSE FIELD

Kiev AVTOMATICHESKAYA SVARKA in Russian No 2, Feb 86
(manuscript received 28 Feb 85, in final version 15 Oct 85) pp 61-62, 67

[Article by V.A. Shishkin, candidate of technical sciences, N.P. Konovalov, engineer, and D.A. Kuznetsov, engineer, Moscow Aviation Technological Institute imeni K.E. Tsiolkovskiy]

[Abstract] Welding together parts made of plastic materials by the magnetic pulse method requires a special device made of an electrically conducting material for conversion of energy from electromagnetic to mechanical. An experimental feasibility study of this process was made for a specific application to plastic tubes. Aluminum alloy 0.5-1 mm thick rings were slipped on tubes 25-50 mm in diameter made of low-density polyethylene, high-density polyethylene, polypropylene, polyvinyl chloride, polystyrene, polyamide, polycarbonate and polytetrafluoroethylene F-4. When such a tube is placed inside the inductor coil, a discharge from the capacitor bank generates eddy currents in the ring and their interaction with the current pulse in the coil causes plastic deformation of the ring which, in turn, generates the pressure necessary to change the diameter of the plastic tube. In the UESO-1 welding machine designed for this purpose at the Electric Welding Institute (UkSSR Academy of Sciences), two tubes to be welded together are held in a sleeve with a clearance allowing for expansion during preheating of the tubes to the temperature appropriate for their given material. Collapse of these tubes under subsequent pressure is prevented by a mandrel with a hook at one end placed inside the tubes before welding and removed after welding. Preheating temperature and welding pressure vary from 120°C and 85 MPa for low-density polyethylene to 160°C and 225 MPa for teflon F-4. The process is also applicable to composite plastics with organic reinforcing fibers such as polyamide SVM for high-pressure hydraulic and pneumatic tubing. The process has also been specially refined for welding composite thermoplastic materials with 50% filler, here the sleeve being made preferably of the same material.

References 4 (Russian).

2415/9835
CSO: 1842/175

EFFECT OF RADIATION ON RADIATIVE AND NON-RADIATIVE RECOMBINATION IN HETERO-SYSTEMS BASED ON GaAs and $Al_xGa_{1-x}As$

Leningrad FIZIKA I TEKHNIKA POLYPROVODNIKOV in Russian Vol 2, No 2, Feb 86
(manuscript received 25 Sep 84, accepted for publication 2 Oct 85) pp 322-325

[Article by O.Yu. Borkovskaya, N.L. Dmitruk, M. Dubovinski, R.V. Konakova, D.V. Korbutyak, Ye.G. Lashkevich, Yu.A. Tkhonik and Ya.Chervenak, Semiconductor Institute, UkrSSR Academy of Sciences, Kiev; Electrotechnical Institute, Center for Electrophysical Research, Slovak Academy of Sciences, CSSR, Bratislava]

[Abstract] Penetrating radiation causes primary radiation defects in crystals, followed by their diffusion and complexing. Heterosystem semiconductors in which one semiconductor is a solid solution were chosen for the present study, in which the effect of low-level gamma radiation by ^{60}Co on radiative and non-radiative recombination in heterosystems of $GeAs-Si_xGe_{1-x}$ and $GeAs-Al_xGa_{1-x}As$ was evaluated. The systems were obtained

by thermal vaporization of Ge or Si_xGe_{1-x} solid solution in a vacuum at 400-500°C on epitaxial $n-n^+$ -GaAs structures, producing precipitated layers 50-5000 Å in thickness. After irradiation, photoluminescent spectra were studied. Results showed that radiation amounting to $5 \cdot 10^5$ rads showed combustion of $h\nu_1$ and $h\nu_2$ bands when the thickness of the Ge layer was 50 Å, by a factor of roughly 2, followed by decline and slight growth of intensity as rad dosage was increased. With a thicker layer, the fall in luminescence was noted more quickly. Changes in the non-radiative lifetime were regarded as key factors in recombination. References 7: 6 Russian, 1 Czech.

121 1/9835
CSO: 1842/183

NEAR-SURFACE BAND BENDING IN GaAs WITH NEGATIVE ELECTRON AFFINITY

Leningrad FIZIKA I TEKHNIKA POLYPROVODNIKOV in Russian Vol 20, No 2, Feb 86
(manuscript received 29 Mar 85, accepted for publication 31 Aug 85)
pp 330-332

[Article by A.D. Korinfskiy and A.L. Musatov, Radio Engineering and Electronics Institute, USSR Academy of Sciences, Moscow]

[Abstract] The efficiency of photoelectron emission from semiconductors with negative electron affinity (NEA) is determined to a considerable extent by the energy relaxation of hot electrons in the area of near-surface band bending. Therefore knowledge of the magnitude of such bending is important for analyzing the mechanism of photoemission from such structures. The need has arisen for directly measuring the magnitude of near-surface band bending on p-GaAs with NEA. The present article discusses the making of such measurements by a photoemission method. The change in the magnitude of band bending in the process of the reduction of the work function on the GaAs

surface is also studied. The photoemission method involves, inter alia, measuring the Fermi energy on the semiconductor surface. Knowing the position of the Fermi level in the bulk of the semiconductor, one can determine the band-bending magnitude. Experiments were performed in a high-vacuum chamber using p-GaAs monocrystals alloyed with zinc and oriented in plane (100). Results indicated that on the surface of NEA GaAs semiconductors, oxygen is bonded not only to cesium but to the overall surface of the semiconductor. Since the position of the Fermi level on the surface relative to the top of the valance zone is independent of the alloying volume, in the $1 \cdot 10^{17} : 1 \cdot 10^{19} \text{ cm}^{-3}$ concentration range, the band-bending magnitude for the GaAs-CsO layer can be determined in terms of a hole concentration of $5 \cdot 10^{18} \text{ cm}^{-3}$, and amounts to 0.45 eV in this instance. References 8: 2 Russian, 6 Western (1 in Russian translation).

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CSO: 1842/183

INTRACENTER ELECTROLUMINESCENCE OF VANADIUM IN GaAs

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 20, No 2, Feb 86
(manuscript received 5 Jul 85, accepted for publication 6 Sep 85) pp 363-365

[Article by V.S. Vavilov and V.A. Morozova, Moscow State University
imeni M.V. Lomonosov]

[Abstract] High-ohm GaAs alloyed with various transitional elements is useful in micro- and optoelectronic applications. The present article reports on a study of vanadium, the lightest and least studied of such element, in such semiconductors. The authors discovered impurity electroluminescence of significant amplitude in GaAs : V at temperatures of 80-300 K. They studied n-GaAs : V with $p \gtrsim 10^7 \text{ Ohm} \cdot \text{cm}$ and $\tau_n \gtrsim 3 \cdot 10^3 \text{ cm}^2/\text{V} \cdot \text{s}$ at 300 K. Specimens in the form of parallelepipeds $1 \times 2 \times 7 \text{ mm}$ were placed in an alternating flat capacitor field and isolated from its plates by dieledtric packing. Results supported the notion that in the first half of the half-life, a field creates carriers which travel to opposite extremes of a crystal, only to return and recombine with radiation in the second half of the semiconductor's half-life. Thus intracenter electroluminescence does not leave its centers, but merely is transformed from its basic state into an excited state and back. References 10: 5 Russian, 5 Western.

12131/9835
CSO: 1842/183

EFFECT OF GASEOUS PHASE ON STRUCTURAL FORMATION OF SILICON CARBIDE MATERIALS

Moscow OGNEUPORY in Russian No 3, Mar 86 pp 5-7

[Article by T.P. Markholiya, I.I. Kozelkova and M.Yu. Gerasimovich, All-Union Institute of Refractory Materials]

[Abstract] The properties of silicon carbide materials depend on the composition and character of the distribution of the binders formed during sintering. Study of the conditions for the formation of a complex binder in SiC-based materials has established the significant role of the gaseous phase. Structural formation in the materials may be affected by the air in the carbon-containing charges as well as by flue gases. In this connection the processes occurring in the material under the influence of the air of the charge and the flue gases were examined with the aid of thermodynamic analysis. It was assumed that the existence of six condensed phases (SiC, Si, C, SiO₂, SiON₂, Si₃N₄) and of a gaseous phase consisting of SiO, O, O₂, CO, CO₂, N₂, H₂O, H₂ and CH₄ in the system was possible. The equilibrium composition of the gaseous phase was found by the simultaneous solution of a system of equations which consisted of the equation of the material balance for oxygen when examining the effect of air and for oxygen and hydrogen in the case of the effect of flue gases as well as of equations of the equilibrium constants of the chemical reactions covering all components of the gaseous phase. The equilibrium composition of the gaseous phase formed during the sintering of SiC material in a carbon-containing charge at 1273-1873 K was calculated on the basis of the results of thermodynamic analysis. It was indicated that a complex binder can be formed during the interaction of the gaseous phase with all components of the charge including with primary SiC. Hydrochemical oxidation of the charge components is one of the prerequisites for the formation of a complex binder. Secondary products may be separated out both during interaction of the solid-gaseous type and from the gaseous phase alone. References 13 (Russian).

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CSO: 1842/184

STUDY OF EFFECT OF GRANULAR COMPOSITION OF SYNTHETIC CORUNDUM ON PRODUCT PROPERTIES

Moscow OGNEUPORY in Russian No 3, Mar 86 pp 7-9

[Article by N.M. Permikina, Ye.Ya. Gimpelman and S.N. Makhonina, Eastern Institute of Refractory Materials]

[Abstract] Rational selection of granulometric composition during semidry compacting permits an appreciable reduction of the compacting pressure needed to obtain a given density. In the present article the authors used the method of mathematical experiment planning to determine the optimal composition of the masses of corundum products fabricated on the basis of PKPS-99 synthetic corundum, using a 4th-order simplex-grid plan to investigate the effect of the granulometric composition of the filler and of the amount of fine-ground component on such properties of the specimens as density, strength and gas permeability. The mass fractions of the 3-0.5 mm and 0.5-0.1 cuts of the synthetic corundum and of fine-ground alumina were chosen as the variables. Three specimens each from 18 compositions (the last three for control purposes in the form of cylinders 36 mm in diameter and 50 mm high) were fabricated under 100 MPa pressure. Orthophosphoric acid was used as the temporary binder. The specimens were sintered at 1700°C and held for 8 h. The linear shrinkage, open porosity, compression strength and gas permeability coefficient were determined. The planning matrix and test results are given in the article. A canonical form of a 4th-power polynomial was chosen as the mathematical model and the regression coefficients were calculated on a "Mir-1" computer. As a result of these calculations an optimal variant with the following composition: 330% of the synthetic corundum of the 3-0.5 mm cut, 50% of the 0.5-0.1 cut and 20% of fine-ground alumina. Corundum articles were fabricated from this charge which were tested with positive results in high-temperature (above 1700°C) furnaces in a hydrogen-containing atmosphere. References 4 (Russian).

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PREPARING LIGHT-WEIGHT HEAT-INSULATED REFRACTORY PRODUCTS WITH OPERATING TEMPERATURES UP TO 1750°C

Moscow OGNEUPORY in Russian No 3, Mar 86 pp 24-28

[Article by Ya.Z. Shapiro, O.V. Zhuchenko and A.N. Gaodu, Ukrainian Scientific Research Institute for Refractory Materials]

[Abstract] Modern requirements dictate the need to develop light-weight refractory products having operating temperatures of up to 1750°C. Presently,

however, Soviet industry only produces heat-insulating refractory materials with a maximum operating temperature of up to 1550°C. The authors' institute has been investigating the fabrications of light-weight refractory materials with operating temperatures up to 1750°C along several lines: using alumina, synthetic corundum, baddeleyite (ZrO_2) concentrate and chromium oxide primarily by semi-dry compacting and also using alumina by the casting method. In fabricating products based on alumina it is not possible to reduce volume shrinkage to less than 17.5% without preliminary treatment. The process is simple and easy to mechanize, however, and the products have high compression strength. Use of a briquette process is most rational for reducing volume shrinkage when fabricating light-weight corundum products by semi-dry compacting. By using various fillers one can obtain products with low shrinkage which do not require machining. Their strength, however, is low. Using the casting method one can produce light-weight corundum products with low apparent density and high strength but they require working to the desired dimensions after sintering. Light-weight heat-insulating products with operating temperatures up to 1750°C can be obtained using baddeleyite concentrate and semi-dry compacting. One can increase the compression strength by varying the chalk content in the charge. Products based on chromium oxide were produced by semi-dry compacting at 25 MPa pressure. Light-weight refractory materials can be produced having a porosity greater than 50% and sufficient strength but with little shrinkage in sintering. The institute's pilot-production plant has produced experimental batches of corundum, baddeleyite and chromium oxide light-weight refractory materials.

References 9 (Russian).

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PREPARATION

UDC: 534.222.2:539.4.019.1:621.7.044

STRUCTURAL CONVERSIONS UPON EXPLOSIVE AND HEAT TREATMENT OF STEEL

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 1, Jan-Feb 86
(manuscript received 18 Apr 84) pp 34-39

[Article by E.A. Savchenkov, V.K. Shashkova and I.A. Shcherbilis, Orenburg]

[Abstract] Continuing earlier studies, the methods of x-ray diffraction and electron microscopy are used to investigate structural transformations upon explosive hardening and heat treatment of type 20 and 30 KHMA steel. The type 20 steel was first normalized and the 30 KHMA steel improved by hardening from 860°C in oil, tempering at 650°C and cooling in water before explosive treatment. Sixteen mm diameter rods, 500 mm length, were hardened by detonating an applied circular surface charge of explosive. The pretreatment to reduce grain size and achieve phased recrystallization of the steel before explosive hardening was intended to retard twinning and achieve slip deformation. Explosive hardening of low-carbon steel under these conditions forms typical vortexed substructures indicating turbulent dislocation-disclination deformation. Vortexes of fan-shaped dislocation tubes join individual sources. Explosive treatment of steel with tempering at 600-650°C forms a dispersed two-stage polygonal cell structure, combining cellular fragmentation and polygonization within cells as the hardening mechanisms. In 30 KHMA steel with sorbite structure, explosive hardening causes carbide dissociation oriented within the shock wave with subsequent carbide dissolution upon tempering up to 500°C. At 600-650°C the dispersion carbides are uniformly redistributed through the substructure.

References 21: 20 Russian, 1 Western.

6508/9835

CSO: 1842/186

UDC: 621.762

STUDY OF INFLUENCE OF TITANIUM AND ZIRCONIUM ON RATE OF SATURATION OF POROUS TUNGSTEN WITH COPPER AND CHANGE IN RESISTIVITY OF THE ALLOY DURING ANNEALING

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 1, Jan-Feb 86
(manuscript received 9 Jul 85) pp 115-117

[Article by A.E. Ligachev, I.N. Pashkov, B.S. Mitin and I.P. Zibrov, Moscow]

[Abstract] A study is presented of the influence of addition of the interphase-active elements titanium and zirconium to copper on the process of saturation and annealing of the alloy. Porous specimens of tungsten powder with a particle diameter of 2-4 μm were pressed in a steel mold and sintered in a vacuum at 1773 K, yielding specimens with a porosity of 43%. The kinetic regularities of the process of saturation of the porous tungsten with alloys in the Cu-Ti and Cu-Zr systems were found to be virtually the same. There are two stages: in the first the limiting factor is the dimensions and configuration of the pore channels while in the second the flow of the melt in the capillaries is slowed by the formation of an oxide film at the leading edge of the moving fluid. As the content of interphase-active elements increases from 4 to 8%, the rate of the process is increased by a factor of approximately 1.5. Tempering of heated specimens increases the resistivity of the alloy, indicating breakdown of the supersaturated α -solid solution. Measurement of changes in resistivity can be recommended for determination of optimal tempering conditions. References 4: 3 Russian, 1 Western.

6508/9835
CSO: 1842/186

UDC 669.15'71'74-194:537.311.31:539.32

ELASTIC AND KINETIC PROPERTIES OF AGING Fe-Mn-Al-C STEEL

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 61, No 2, Feb 86 (manuscript received 25 Jan 85, in final version 14 Mar 85) pp 273-277

[Article by V.S. Litvinov, V.D. Kibalnik, S.D. Karakishev and I.S. Kalashnikov, Ural Polytechnic Institute imeni S.M. Kirov and All-Union Scientific Research Aviation Materials Institute, Moscow]

[Abstract] An experimental study of the austenitic iron-manganese steel 90G28Yu9VBMSh (DI-38Sh) was made, for the purpose of determining the temperature dependence of its modulus of normal elasticity and of its electrical resistivity as well as of their temperature coefficients over the -196-(400) $^{\circ}\text{C}$ range after austenitization and after age hardening. Two industrial samples of that steel (28% Mn, 9.0% Al, 0.7% V, 0.5% Nb, 0.4% Mo)

containing 0.86% C and 0.95% C respectively were quenched in water from 1050°C for austenitization and then again with subsequent age hardening at 520-550°C for 15-20 h. Mössbauer spectra obtained by nuclear-gamma-resonance spectroscopy at room temperature indicate a paramagnetic austenite without a magnetic superfine structure. The temperature dependence of its modulus of normal elasticity is characterized by an anomalous sharp dip and a correspondingly sharp peak of the temperature coefficient within the -70-(-30)°C range, indicating an antiferromagnetic transition in the γ -phase. This magneto-elastic effect was found to be weaker in the steel with a higher carbon content, the Neel point dropping from -50°C for the 0.86% C steel to -55°C for the 0.95% C steel. The temperature dependence of their electrical resistivity is characterized by a soft dip and a correspondingly soft peak of the temperature coefficient within the 60-120°C range, the temperature coefficient of electrical resistivity becoming zero at about +75°C and increasingly negative with decreasing temperature. Aging was found to increase the modulus of normal elasticity throughout the entire temperature range, with a smoothing of the dip so as to make it decrease monotonically with rising temperature. Aging was also found to decrease the electrical resistivity and increase its temperature coefficient in the subzero temperature range, but to slightly increase the former and decrease the latter from room temperature up. Evidently, therefore, the properties of this steel and their temperature dependence differ significantly from those of the G29 (29% Fe) steel. References 13 (Russian).

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USING CHIPS OF TITANIUM ALLOYS FOR PRODUCTION OF TC-TYPE HARD ALLOYS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 2, Feb 86
(manuscript received 27 Feb 86) pp 27-30

[Article by S.S. Kiparisov, Yu.V. Levinskiy, A.P. Petrov and I.P. Deulina, Moscow Fine Chemical Technology Institute]

[Abstract] A hard alloy of the TC type was produced experimentally from a 200 kg batch of nonstoichiometric titanium carbide, with a mixture of milling chips of the VT-3-1 alloy and Pt-15TS soot serving as the raw material. The 0.5 mm thick, 20 mm wide, 50 mm long chips were carbidized in a tubular graphite furnace at a temperature below the melting point of titanium, on trays moving at a speed of about 0.9 cm/min with hydrogen supplied at a rate of 1.5-2 m³/h. Depending on the Ti:C ratio in the raw batch, the carbide contained 11-20% C (1.5-4.5% free carbon, 9.5-15.5% bound carbon), 1.0-1.2% O₂, and 1.1-1.4% N₂. The titanium-to-carbon ratio was maintained within a range ensuring a sufficiently low amount of bound carbon for subsequent production of the complex (Ti,W) carbide. A significant amount of free carbon detrimentally affects the properties of this complex carbide. After the carbide sinter had been crushed in ethyl

alcohol for 48 h into powder with 76.3% of particles not larger than 5 μm and with the mean dimension of particles 4 μm , the complex (Ti,W) carbide and the T5K10 hard alloy were produced by conventional powder-metallurgy processes under simulated industrial conditions. The properties of the product, namely density, magnetic coercive force, ultimate mechanical strength in flexure, and stability index in cutting are comparable with those of the commercial T5K10 hard alloy, within the certified quality range. A cost analysis indicates that use of chips is more economical. The authors thank A.S. Suvorov, V.N. Oganesyan, and A.A. Novgorodova for tremendous help in the project. References 6: 4 Russian, 2 Western (1 in Russian translation).

2415/9835
CSO: 1F.2/172

UDC 621.9.048

ELECTRODE MATERIALS BASED ON REFRACRYOR BORIDES FOR ALLOYING BY ELECTRIC-SPARK PROCESS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 2, Feb 86
(manuscript received 13 Mar 85) pp 30-33

[Article by A.D. Verkhoturov, I.A. Podchernyayeva, F.F. Yegorov and E.G. Babenko, Mining Institute, Far Eastern Scientific Center, USSR Academy of Sciences, and Institute of Materials Science Problems, UkrSSR Academy of Sciences]

[Abstract] Refractory borides of metals in the transition group, characterized by a high hardness level and resistance to scaling, are eminently suitable for electrodes used in the electric-spark alloying process. The main criteria for a high liquid content in the products of erosion of the alloying material are: selection of a cathode-anode pair which will ensure mutual solubility of the cathode material and the plasticizing binder component of the boride-base material and wettability of the cathode material and the refractory component of the boride-base material by the binder component; optimum binder content; preferred "ring" structure of the alloy with a grain of the disperse solid boride phase surrounded by the binder phase and transported to the cathode by the intercrystallite fracture mechanism; and optimum relation between the thermophysical properties of the two electrode materials: thermal conductivity and melting point of the anode material not more than 4-5 times higher than those of the cathode material. With these criteria met, the tribological characteristics of the TiB_2 -Mo composite were measured on an M-22P friction machine and evaluated by the method of differential thermal analysis on an OD-103 derivatograph. Wear rate and scaling rate, also hardness of the alloy layer at 20°C and the coefficient of friction at 300°C and 500°C have been determined for electrodes containing 5-80% Mo. The results indicate suitability of this

composite for improvement of the wear resistance of cutting tool steels, stamping die steels, and steel parts of machines operating under abrasive friction at elevated temperatures. A binder more plastic and scale-resistant than molybdenum may be required for some applications. References 7 (Russian).

2415/9835
CSO: 1842/172

UDC 621.762.4:669.3:621.3

PRODUCTION OF MATERIALS BY ELECTRIC-DISCHARGE SINTERING OF PULVERIZED BRONZE CHIPS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 2, Feb 86
(manuscript received 15 Feb 85) pp 41-44

[Article by A.I. Raychenko, A.S. Morozov and V.P. Ponov, Institute of Materials Science Problems, UkrSSR Academy of Sciences]

[Abstract] Sintering of bronze chips by electric discharge, more precisely electric microdischarges between particles during passage of electric current through a fine-disperse chip, was tried experimentally on 3-9 mm long chips of BrZh 9-4 aluminum bronze. Such chips are produced when a rod is turned on a lathe at a cutting speed of 15.7 m/min and a feed rate of 0.175 mm/rev, 0.2 mm deep per pass. Such chips were washed in soda solution and crushed with laboratory beaters into powder within the 0.15-0.35 mm size fraction. Bar specimens 50 mm long with a 5x5 mm² cross-section and ring specimens with an outer diameter of 25 mm, 2.5 mm thick and 4 mm high, were produced by sintering this powder according to the conventional technology: compaction under low pressure during passage of electric current and subsequent application of high pressure. While the electrophysical properties of specimens sintered by this method were found to closely approach those of commercially cast ones, their mechanical properties were found to be somewhat worse and acceptable only for articles or machine parts not required to carry heavy loads. A cost analysis indicates that such a processing of chips is highly economical, inasmuch as it reduces metal waste to 37 or less and the cost of material for bronze products correspondingly by a factor of almost 2.5 the cost of material for bronze products. The chip surface must, however, be free of oxide films and lubricant-coolant fluid.

References 2 (Russian).

2415/9835
CSO: 1842/172

UDC 621.762.4:669.295:669.76:621.89

MECHANICAL PROPERTIES OF TITANIUM IMPREGNATED WITH BISMUTH ALLOY

Kiev POROSHIKOVAЯ METALLURGIЯ in Russian No 2, Feb 86
(manuscript received 2 Apr 85) pp 83-86

[Article by V.G. Yenevich, V.A. Pisarenko and L.I. Tuchinskiy, Institute of Materials Science Problems, UkrSSR Academy of Sciences]

[Abstract] The mechanical properties of titanium pseudoalloys consisting of a titanium powder matrix and a fusible bismuth alloy as impregnant were measured, these materials being characterized by the high wear resistance desirable for friction pairs. Test specimens were produced from PTEM-2 electrolytic titanium powder with +0.04-0.18 dispersion, by sintering and subsequent impregnation. Ultimate tensile strength and percentage elongation at room temperature were determined from stress-strain curves plotted on a 1231U10 universal machine at a strain rate of $1.1 \cdot 10^{-3}$ s⁻¹, using standard cylindrical specimens. Compressive strength was measured on a TsD-20 machine, using 20 mm long square bar specimens with 10x10 mm² cross-section. Flexural strength was measured on an R-5 machine, using 55 mm long rectangular bar specimens with 5x10 mm² cross-section and 40 mm distance between supports. Impact strength was measured with a KM-5 ram, using notchless 55 mm long square bar specimens with 10x10 mm² cross-section. Hardness was measured with a TK-2 tester. The volume fraction of bismuth alloy and the porosity of the composite material were varied over the 10-50% range. All mechanical properties were found to peak, with the maximum corresponding to a 20-25% volume fraction of bismuth alloy, and to decrease monotonically with increasing porosity of the composite material. The strength of the bismuth alloy is low, not higher than 30 MPa, but by equalizing the stresses in the titanium skeleton it yields a composite material with a strength 1.5-2 times higher than that of titanium skeletons prior to impregnation. References 8: 7 Russian, 1 Czechoslovak.

2415/9835
CSO: 1842/172

UDC 666.798.2

DEPENDENCE OF MECHANICAL PROPERTIES ON COMPOSITION OF Si₃N₄-BASE MATERIAL

Kiev POROSHIKOVAЯ METALLURGIЯ in Russian No 2, Feb 86
(manuscript received 28 Oct 82) pp 93-96

[Article by G.A. Cogotsi, Ya.L. Grushevskiy, N.N. Zudin, G.V. Trunov and O.D. Shcherbina, Institute of Materials Science Problems and Strength Problems Institute, UkrSSR Academy of Sciences]

[Abstract] Powder materials on a Si₃N₄ base with various amounts of SiC as second component have been studied extensively, because at high temperatures

they are mechanically stronger and have a higher thermal conductivity than plain Si_3N_4 material. One study was made for the purpose of optimizing the composition, with silicon added to the mix, and developing the technology of reactive bonding in a nitrogen atmosphere with subsequent activated sintering in a powder mold. The ingredients for test specimens were commercially pure Si_3N_4 powder with a 3 μm mean grain size, K3 SiC powder with a 15 μm mean grain size, KR-0 Si powder with a 30 μm mean grain size, and electrically smelted MgO powder with a 0.5 μm mean grain size as activator. Specimens of all compositions were produced by pouring the thermoplastic dross and sintering in an induction furnace, first isothermally at 1350°C for 1 h and then isothermally at 1560°C for 2 h, with subsequent annealing at 1100°C for 2 h in air. Strength was selected as the optimality criterion for the composition since deformability and cracking resistance at normal temperatures had been found to hardly vary with the composition. Rectangular bar specimens 60 mm long and 3.5x5.0 mm^2 in cross-section were ground with a diamond wheel prior to being tested on a TsD-4 machine at 20°C and at 1400°C. An evaluation of the tests data with the aid of incomplete cubic Schaeffe polynomials for strength $\sigma = B_1x_1 + B_2x_2 + B_3x_3 + B_{12}x_1x_2 + B_{13}x_1x_3 + B_{23}x_2x_3 + B_{123}x_1x_2x_3$

(x_1, x_2, x_3 - weight fractions of Si_3N_4 , Si, SiC respectively) and a seventh-order system of linear equations solvable by the Gauss method for the B-coefficients has revealed that at 20°C the strongest material is one without Si_3N_4 and at 1400°C the strongest material is one with approximately 50% Si_3N_4 + 30% SiC + 20% Si. References 8: 6 Russian, 2 Western (1 in Russian translation).

2415/9835
CSO: 1842/172

UDC 669.295.7

HIGH-STRENGTH Ti + 5% Al + 2.5% Fe ALLOY AND ITS USE AS MATERIAL FOR SURGICAL IMPLANTS

Moscow TSVETNYYE METALLY in Russian No 3, Mar 86 pp 69-74

[Article by U. Zwicker, professor, Department of Materials (Metals) Science, Erlangen-Nürnberg University (FRG)]

[Abstract] A high-strength titanium alloy without vanadium has been developed for surgical implants subject to extra-high flexural stress while in frictional contact with the bone. Selection of titanium as the principal component is based on evidence in experimental monkeys that, within 100 days, a titanium-bone joint becomes mechanically stronger than the bone, while avoidance of vanadium is dictated by the allergic reaction this metal, as well as nickel and cobalt, causes. The alloy is Ti + 5% Al + 2.5% Fe, this composition being most favorable on the basis of metallographic analysis and phase diagrams of the Ti-Al system and the Ti5Al-Fe system, with the heat treatment optimized according to the isothermal transformation diagram. Its

mechanical properties were measured and its microstructure was examined after hot working at 850°C. Wrought and cast prostheses for replacement of the tibial bone were tested for fatigue resistance under a load consisting of 1.0(max)-0.4-0.8-0.0 stress cycle and for friction torque in a ball-and-socket hinge joint with a polyethylene socket. The tests were performed with the active material immersed in a 0.9% aqueous NaCl solution at 39°C, under a hydraulic machine applying vertical pulses, all tests having been designed to simulate real-life conditions. Wrought prostheses with oval cross-section were found to have the highest fatigue resistance, $7.5 \cdot 10^6$ cycles with 600 MPa maximum stress and $86 \cdot 10^3$ cycles with 900 MPa maximum stress, better than the fatigue resistance of wrought prostheses with rectangular cross-section and much better than that of prostheses made of a Co-Cr-Mo alloy even with oval cross-section. It is also higher than the fatigue resistance of centrifugally cast prostheses, but the latter can be raised to almost the same level by quenching in water from an annealing temperature in the β -phase region and subsequent hot working at 800°C to a 25% reduction. A low friction torque, comparable with that in an alumina-polyethylene pair, is attainable by polishing the alloy surface after the member has been held at 850°C for even 10 min only and then quenched in oil. Since the powder technology has already been successfully applied to this Ti + 5% Al + 2.5% Fe alloy, it appears quite feasible to use it as a porous sintered material for implants with a modulus of elasticity lower than that of wrought or cast alloy but still close to that of a bone. Tests on experimental rabbits revealed no chemical reaction in the biological bone tissue in permanent contact with this alloy. References 16: 3 Russian, 13 Western.

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CSO: 1842/215

UDC 621.762

CORROSION RESISTANCE OF FINE-DISPERSE IRON AND Fe-Co-Ni ALLOY POWDERS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 86
(manuscript received 20 Jul 83) pp 1-3

[Article by Z.M. Melnichenko, G.K. Rashevskaya, A.G. Zhigotskiy, L.G. Borodina and T.M. Shvets, Colloidal Chemistry and Hydrochemistry Institute, UkrSSR Academy of Sciences]

[Abstract] The corrosion resistance of fine-disperse iron powders and 60% Fe + 30% Co + 10% Ni powder was tested in water and in 25% aqueous KOH solution. Both powders had been produced by the electrolytic deposition process. The iron powder contained 52.1 wt.% active metal. The powder alloy, containing 59.7 wt.% active metal with a dendritic grain structure characterized by an anisotropy ratio ranging from 1:5 to 1:7 and a larger dimension within the 200-500 nm range, was modified by successive treatment with 1.5%, 4.5%, 7.5% A-15-0 vinyl chloride + vinyl acetate copolymer and then oxyphos- Λ to correspondingly 53.0-49.2-45.2-60.0 wt.% active metal without

change in grain structure. The change in magnetic induction served as the measure of corrosion. The readings of specific residual and saturation magnetization

$(\frac{A/m}{kg/m^3} = A \cdot m^2/kg)$ and coercive force (kA/m) have revealed,

accordingly, that iron powder, even with chemisorbed oleinic acid as surfactant, corrodes in both water and alkali solution. Its corrosion in water was most intense during the first 3-4 days and almost completely ceased after 15 days, while in alkali solution its corrosion continued even after 15 days. The alloy powder was found to be much less surface active and, therefore, much more corrosion resistant, its corrosion resistance being further enhanced by the presence of protective organic surface films. References 13: 9 Russian, 2 Czechoslovak (both in Russian translation), 2 Western (both in Russian translation).

2415/9835
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UDC 660.04:621.039.61

FORMS OF OXYGEN BOND IN FINE-DISPERSE MOLYBDENUM POWDER AND FEATURES OF COMPLETE-REDUCTION ANNEALING

Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 86
(manuscript received 15 Jan 85) pp 10-13

[Article by R.U. Kalamazov and A.T. Ibragimov, All-Union Scientific Research and Planning Institute of Refractory Metals and Hard Alloys, Chirchik branch]

[Abstract] Fine-disperse molybdenum powder stored in air for a long time will adsorb up to 15 vol.% oxygen within a month and retain at least 80% of it in the form of inclusions, most of this oxygen coming from water vapor and some of it from CO_2 . Plain desorption treatment can lower the water content by 50% at room temperature and by 95% at $100^\circ C$, but desorption of oxygen ceases at $300^\circ C$. Processing of the powder requires that the oxygen content be lowered to within 0.2 vol.%, which calls for complete-reduction annealing without changing the essential properties of the powder. Auger-electron spectrometry and x-ray phase analysis have revealed the forms of oxygen bond in the powder. Accordingly, the intensity of oxygen Auger peaks was found to have two maxima within the electron-beam energy spectrum: one at 1.5 keV indicating the oxygen concentration on the surface of molybdenum particles and one at 3 keV indicating the oxygen concentration in the subsurface layer. Molybdenum was found to remain metallic in the presence of 4-5 wt.% oxygen and to be gradually converted into Mo_2O_3 oxide only by oxygen in higher concentrations, a 100% complete conversion being facilitated by vacuum annealing at $300^\circ C$. Since evidently not all the adsorbed oxygen participates in this process, some of it must be remaining in a chemically bound but x-radiographically amorphous state. Complete reduction by annealing in a hydrogen stream not only ensures complete removal

of oxygen from the powder but also allows control of the powder grain size by temperature-time regulation. An analysis of the reduction kinetics indicates that such annealing at 700°C will remove the oxygen completely within 3 h. Since water is the principal oxidizing agent here, it is not paradoxical to recommend that fine-disperse molybdenum powder be stored preferably in a dry oxygen atmosphere. References 5 (Russian).

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UDC 621.762

STRUCTURIZATION OF Al-Cu ALLOY DURING SINTERING

Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 86
(manuscript received 5 Jun 85) pp 19-23

[Article by A.P. Savitskiy and G.N. Romanov, Institute of Strength Physics and Materials Science, Siberian Department, USSR Academy of Sciences]

[Abstract] Dimensional and structural changes in Al-Cu powder alloy compacts during liquid-phase sintering were studied, solid solutions forming on the surface of aluminum grains during growth by melting with attendant spreading in the first of at least two discernible stages and shrinkage with retention of the liquid phase at grain boundaries occurring in the second stage. Specimens were produced from a mixture of ASD-1 aluminum powder with 6 wt.% Cu, more than would completely diffuse into aluminum, pressed to 78% of the maximum theoretical density for molding into 10 mm long cylinders 10 mm in diameter and sintered in a vacuum dilatometer at 620°C for successively longer periods of time. Photographs taken on Mikrat-300 film under an MIM-8 microscope, after microsection had been chemically etched with an 8.7 vol.% HF + 12.6 vol.% HCl aqueous solution, reveal formation of a polyhedral "cast" microstructure first replacing the finer aluminum grains and eventually covering the entire mold volume. According to the dilatograms, however, this second stage occurs only when the equilibrium composition of the alloy powder at the sintering temperature lies within the melting range on the fusibility diagram. Powder with copper deficiency has been found to become completely sintered within the first stage, without subsequent shrinkage. References 3: 1 Russian, 1 Yugoslav, 1 Western.

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UDC 621.762.669.018.5

SELECTION OF RAW POWDERS FOR PRODUCTION OF SINTERED PERMALLOYS

Kiev POROSHIKOVAYA METALLURGIYA in Russian No 3, Mar 86
(manuscript received 10 Apr 85) pp 24-27

[Article by Ye.M. Minayev, Kuybyshev Aviation Institute]

[Abstract] Powders for production of sintered magnetically soft Fe-Ni alloys must, in addition to being of high chemical purity, be highly "active" during sintering. Although a most homogeneous product is obtained from alloy powder by simultaneous reduction of Fe and Ni oxides or decomposition of Fe and Ni carbides, by simultaneous electrolytic deposition, or by pulverization of the melt, sintered permalloys are also produced from mixtures of Fe and Ni powders. With carbonyl iron powder already established as most suitable for this purpose, a further study was made to determine the most suitable nickel powder on the basis of its "activity" during sintering. Three grades of carbonyl nickel powder were evaluated: 1) light PNK1L6, 2) heavy PNK1T2, 3) electrolytic PNE1. Specimens of each were compacted under a pressure of 500 MPa into rings with 35.5%, 26.7% and 23.5% porosity and sintered in a hydrogen atmosphere at 500°C, 700°C, 900°C, 1100°C and 1300°C without soaking at these temperatures. Porosity, electrical resistivity, initial and maximum magnetic permeability, saturation induction, and coercive force served as indicators of "activity". The results reveal that light carbonyl nickel powder PNK1L6 is the most "active" and therefore most suitable one for sintered permalloys, those produced with these powders having the lowest electrical resistivity and highest magnetic properties. References 5: 4 Russian, 1 Western (in Russian translation).

2415/9835
CSO: 1842/182

UDC 669.14.018.298.3:620

KINETICS OF AUSTENITE-TO-BAINITE TRANSFORMATION AND INTERNAL STRESSES IN BALL-BEARING STEEL DURING QUENCHING

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 4, Apr 86 pp 22-24

[Article by A.N. Kulakov, A.S. Kagan and A.A. Kapyrin, All-Union Scientific Research and Design-Technological Institute of the Bearing Industry]

[Abstract] An experimental study of three ball-bearing steels (ShKh20SG, ShKh15SG, type ShKh15SGM) was made pertaining to the kinetics of transformation from austenite to lower bainite during quenching after austenitization. Plain oil quenching from the austenitization temperature (830°C, 855°C, 840°C)

after 25 min in each case was followed by tempering at temperatures of 170-220°C for 3-25 h in a salt bath (53% KNO_3 + 40% NaNO_3 + 7% NaNO_2) with 2-3% H_2O and subsequent air cooling. Isothermal quenching from the austenitization temperature to 220-230°C was followed by soaking for 25 h and subsequent air or oil cooling. The transformation kinetics and the residual austenite were tracked by magnetic measurements with an Akulov anisometer and a ballistic magnetometer. The lattice period of residual austenite was measured in a DRON-1.5 x-ray diffractometer with a CoK_α -radiation source, using a plate of 99.99% pure copper as reference standard. Carbon content and martensite content were determined from the interdoublet distance according to the third-moment method. Residual stresses of the first kind under the surface of square specimens 40x40 mm^2 , 50x50 mm^2 , 60x60 mm^2 in cross-section were measured by the $\sin^2\phi$ method in a DRON-2 x-ray diffractometer with a CrK_α -radiation sources. The tensile stresses after quenching were found to decrease after tempering at higher temperatures for longer periods of time. Soaking at 220-230°C was found to increase the lattice period of residual austenite, to first increase and then decrease the amount of residual austenite, and eventually reduce the residual tensile stresses 0.3-0.5 mm below the surface to zero. Lowering the silicon content to 0.46% Si and the manganese content to 0.66% Mn (ShKh15SGM steel) was found to accelerate the bainite formation at that soaking temperature. References 9: 8 Russian, 1 Western.

2415/9835
CSO: 1842/195

TREATMENTS

INCREASED USE OF LASER TECHNOLOGY IN METALLURGY

Moscow PRAVDA in Russian 12 Feb 86 p 6

Article by A. Presnyakov: "The Beam is Gathering Strength--Along with the Researcher"

Text Here in the laboratory of the Institute of Metallurgy imeni A. A. Baykov of the USSR Academy of Sciences they are searching for new functions of the laser. During their research they have discovered the physical effect of forming plasma with a laser beam and they have studied and planned ways to use this effect in technology.

The laboratory director, Doctor of Technical Sciences and winner of the USSR State Prize A. Uglov, is talking about the importance of the research which has been conducted, about the details of the burst and the behavior of the plasma created--a gaseous microcloud heated up to tens of thousands of degrees.

"Today the maximum concentration of energy flows used largely determines production intensification, the increase in production output volume per unit of time, and the rise in the quality of products," says the professor. "Following this formula, scientists and engineers are searching for new powerful energy carriers. Among them, hot gas flows, electron beams, and electric arc plasmatrons are receiving all the wider dissemination. The time has also come for the beam of the optical quantum generator--the laser. Here the energy-flow density can be raised millions of times higher than with the help of other of its well-known carriers. This is important for metallurgy as the most energy-consuming industry as well as for other industries. The powerful beams are used for welding, cutting, thermal treatment, and surface super-strengthening of metals."

The professor is showing one of the experimental chambers which permit the accomplishment of an impressive program of scientific research. Its massive body is capable of withstanding a pressure of many atmospheres. The chamber "associates with" the external atmosphere by three openings. One opens the way for the laser beam, the second permits a peek inside the lens of the high-speed camera, the third de-excites the plasma to the spectrometer. Recording and measuring equipment eases the "dialogue" with the plasma for the researchers. A target--a metallic plate, is placed in the chamber's womb. Compressed nitrogen is fed into the chamber through a pipeline from a high-pressure tank.

"The plasma process is born at the moment that the laser beam, aimed at the target, is sent through the chamber window," the scientist explains. "A plasma bunch, heated up to tens of thousands of degrees, is formed at this instant in the target zone under high nitrogen pressure. Even a single 'shot' of a beam causes chemical bonds of gas with metal. Carefully examining the target after a single irradiation, a patch of golden nitride can be observed on its surface. If a carbide has to be obtained, replace the nitrogen with carbon dioxide or methane. Then carbon, which easily enters into reaction with the metal and forms a carbide, splits off from the carbon dioxide or methane."

Nitrides and carbides have very high hardness and heat-resistance. These important physicomechanical properties, which are imparted to machine parts and units during the treatment by plasma technology, bring about an extended service life for articles. That is why specialists of a number of industries are showing interest in this innovation.

Scientific metallurgists are now conducting joint studies with specialists from VNII/All-Union Scientific Research Institute of Drilling Equipment on the subject of strengthening articles. The inadequate sturdiness of the most important unit of the drilling rig--the bearing, causes many troubles when drilling test and industrial wells for oil, natural gas, and water. It often breaks down, delays develop, and work productivity is lowered. Strengthening the bearings promises to yield a large economic impact.

A similar problem has united the scientists of the academic institute with the engineers of the enterprises of the NPO/scientific production association Remdetal which reconditions agricultural equipment. Plasma technology also helps to restore and effectively strengthen medical equipment articles. In cooperation with engineers of the NPO Medinstrument, scientists are carrying out joint developments on increasing the service life of scalpels, surgical needles, and other of the most delicate instruments.

Laser plasma technology is gathering strength in industry.

8524
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PLASMA-ARC HEAT TREATMENT OF THE SURFACE OF IRON-CARBON ALLOYS

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 1, Jan-Feb 86
(manuscript received 23 Oct 84) pp 52-55

[Article by N.V. Livitan, S.P. Polyakov and Yu.K. Bunina, Dnepropetrovsk]

[Abstract] A study is presented of the influence of the technological parameters of the process of plasma-arc heat treatment of the surfaces of products made of iron-carbon alloys on changes in their structure and microhardness, using the treatment of type SP-62 cast iron rolls as an example. Plasma arc treatment was performed on specimens measuring 10 X 10 X 20 mm cut from the rolling surface of a mill roll and placed around the edge of a solid graphite disk with slots for the specimens, achieving a high degree of similarity of the thermal processes and structural changes in the specimens with those which occur in the roll when it is treated as a whole. Metallographic studies of the specimens treated showed that the plasma arc has an effect similar to laser treatment and induction surface hardening. The depth of the melted zone in the surface layer depends on the parameters of the plasma-arc treatment, increasing from 150 to 1200 μm with a decrease in speed of movement of the heat source of 0.4 to 0.12 m/s and an increase in the heat flux density in the specimen of 4.5 to 5.5 kW/cm^2 . A martensite-cementite or troostite-cementite fine crystalline structure possessing increased hardness and wear resistance is formed in the melted zone. Increasing heating time slightly decreases the degree of dispersion of the structural components as well as microhardness. References 6 (Russian).

6508/9835
CSO: 1842/186

LOCAL ALLOYING OF SINTERED HARD-ALLOY ARTICLES

Kiev POKUSHKOVAYA METALLURGIYA in Russian No 2, Feb 86
(manuscript received 16 Apr 85) pp 33-37

[Article by A.F. Lisovskiy, N.V. Tkachenko, T.E. Gracheva and
Ye.S. Cherepenina, Superhard Materials Institute, UkrSSR Academy of Sciences]

[Abstract] The ability of sintered composite materials consisting of a refractory component and a more easily fusible binder to absorb any metal melt wetting the surface at a temperature higher than the melting point of the binder has been utilized for injection of various alloying additives into select regions or parts of nonporous hard-alloy articles. The liquid phase penetrates quite deeply so that the absorbed melt can implant an alloying additive at the absorption temperature. Since the alloying process occurs after the article has been structurally formed, an additive will not influence the process of solid-phase and liquid-phase sintering. The method was tried on sintered Ni-WC alloys. Into specimens of the VN6 alloy (6% Ni + 94% WC) consisting of 35 mm long bars 5x6 mm² in cross-section with a porosity not exceeding 0.1% and with carbide particles not larger than 3 μ m, there were injected metals forming carbides (Ti, Cr), metals not forming carbides (Co, Fe), and a nonmetal (Si). The alloying element was transported principally by way of absorption of the nickel melt saturated with tungsten and carbon (60% Ni + 40% WC) by the VN6 alloy. The maximum injectable amount of an alloying element is determined by the solubility of nickel in the melt at the absorption temperature. The effect of alloying elements on the migration of the nickel melt within a specimen of the VN6 alloy was determined in two series of tests, one with the nickel melt containing only chromium + carbon (40% Cr₃C₂ instead of 40% WC) and one with 40% WC but iron or cobalt partly replacing the nickel. Metallographic and x-ray spectral analyses have revealed that isobaric-isothermal absorption of its own nickel melt by the VN6 alloy and subsequent soaking for 10 min produce a long zone with a large amount of binder metal. The second zone, not penetrated by the alloying additive, has also a high nickel content and in the third zone the initial ratio of binder metal to carbide phase is retained. The highest concentration of an alloying element is found within the zone of contact between the solid VN6 alloy and the nickel melt. Alloying elements, including silicon, were found to increase the flexural strength and the impact strength within the target region, with only a slight attendant decrease of density and hardness.

References 2 (Russian).

2415/9835
CSO: 1842/172

DEVELOPMENT OF GRAIN ORIENTATION IN POWDER MAGNETS IN ALTERNATING AND CONSTANT MAGNETIC FIELDS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 2, Feb 86
(manuscript received 28 Nov 83) pp 96-100

[Article by G.I. Yaglo and A.S. Koteney, Rostov-na-Donu Institute of Agricultural Machinery Building]

[Abstract] A method of attaining grain orientation in powder magnets has been developed, namely by means of an alternating magnetic field and a constant one. This method applies particularly well to high-coercivity rare-earth-cobalt permanent-magnet materials, powders of these materials being characterized by strong magnetostatic interaction of particles which cluster into floccules. The goal of grain-orienting such magnets is to break up these floccules and to properly align the separated individual particles prior to compaction. This is achieved in three stages. First a strong nonuniform alternating magnetic field is applied which sets particles in oscillatory-rotary-translatory motion with attendant weakening of their interaction. Complete separation of particles requires an alternating magnetic field of matched amplitude and frequency. Particles, which are of diverse sizes and have been magnetized to various levels, move then in a complex pattern making the powder swell and occupy the entire mold prior to compaction. Next a constant magnetic field applied perpendicularly to the alternating one controls the oscillatory-rotary motion of powder particles, a sufficiently strong such field causing their motion to decrease and their interaction to increase till they cluster into chains with proper alignment. Reorientation as a result of mechanical interaction during subsequent compaction is avoided by applying the constant magnetic field already in the first stage together with the alternating one. After compaction, in the fourth stage of the process, the alternating magnetic field is turned off and then also the constant one. The equipment for this process includes an electromagnet which produces the constant magnetic field and a permeameter which produces the alternating one. The permeameter has an \square -core with two coils, one wound on each arm, connected in series and energized from a variable-frequency audio oscillator through a variable-gain amplifier. The mold is mounted in the center of this \square -frame, between two coil-carrying arms, in the gap between the two poles of the d.c. electromagnet. The mold consists of two dies, an upper one made of textolite with two punches and a lower one made of metal with a punch on spring support. The equipment was used experimentally for producing SmCo₅-powder magnets with grain orientation. The process parameters, namely magnitude of the constant magnetic field, amplitude and frequency of the alternating magnetic field, and timing of the two magnetic fields, still need to be optimized for maximum effectiveness. References 3 (Russian).

2415/9835
CSO: 1842/172

EFFECT OF HEAT TREATMENT ON STRUCTURE AND MAGNETIC PROPERTIES OF
 $\text{Ce}(\text{Co},\text{Cu},\text{Fe})_6$ ALLOYSKiev POROSHKOVAYA METALLURGIYA in Russian No 2, Feb 86
(manuscript received 25 Mar 85) pp 101-104[Article by A.A. Pavlyukov, O.S. Opanasenko, Ye.I. Gikhman and
E.V. Krakovich, Institute of Materials Sciences Problems, UkrSSR Academy of
Sciences]

[Abstract] An original experimental study of $\text{Ce}(\text{Co}_{0.87-y}\text{Cu}_{0.13}\text{Fe}_y)_6$ magnetic alloys with exceptionally high energy product was made, for the purpose of gathering data on their structure and magnetic properties after heat treatment. Ingots of these alloys were smelted in an electric-arc furnace with a nonconsumable tungsten electrode and a water-cooled copper hearth in an argon atmosphere. They were crushed in a ball mill with ethyl alcohol into a powder of 0.4 μm grain size, whereupon the powder was compacted under a pressure of 707 kgf/ m^2 in a magnetic field of 1200 kA/m intensity and sintered at 1390 K for 0.5 h. Supplementary heat treatment consisted of quenching in liquid gallium and aging in a vacuum furnace for 2 h at various temperatures covering the 670-970 K range. Structural examination by x-radiography of single crystal fragments, with a CrK_{α} -radiation source, was performed after quenching from 1370 K and after aging at 670 K, 770 K, 870 K, 970 K. Hysteresis loops were plotted after quenching, with magnetizing fields of 265-1750 A/m intensity, and the coercive force was measured after aging at each temperature. The results reveal a definite unique relation between coercive force and heat treatment, which indicates identical structural transformations in all alloys of this group. Neither the coercive force nor the x-radiograms had been changed by aging at 770 K or lower temperatures, but had been changed by aging at 870 K or higher temperatures. The representative alloy of this group, $\text{Ce}(\text{Co}_{0.76}\text{Cu}_{0.13}\text{Fe}_{0.11})_6$, is a supersaturated solid solution with ordered structure of the $\text{Th}_{23}\text{Si}_{17}$ kind based on a CaCu_5 kind of elementary cell. References 6: 2 Russian, 4 Western (1 in Russian translation).

2415/9835
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USE OF NbC HEATERS FOR GROWING SiC SINGLE CRYSTALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 2, Feb 86
(manuscript received 12 May 94) pp 104-106

[Article by V.S. Kindysheva, L.F. Maltseva and Yu.M. Shashkov, Institute of Materials Science Problems, UkrSSR Academy of Sciences]

[Abstract] An electric heater made of NbC tubes was used experimentally for growing single crystals and films of hexagonal c-SiC , instead of a graphite heater which breaks down at the required temperatures of 2400-2700°C. The array of NbC tubes was mounted inside the furnace chamber vertically on a common graphite ring and the upper end of each tube was connected to a current lead through a graphite guide bushing. The sublimation chamber was formed by a hollow graphite cylinder with lids and a cylindrical graphite insert with holes not larger than 1 mm in diameter. Polycrystalline SiC was poured into the annular space between them. The single crystals were to grow on the surface of the insert. Heating proceeded in two stages, first to 1300-1500°C in vacuum under a residual pressure of 0.1 Pa and then, after 2 h holding time, to 2700-2900°C in argon under a pressure of 0.1 MPa. After 6-25 h of total heating time, the furnace was cooled down to 1000°C while still containing argon and then to room temperature under vacuum. The compatibility of NbC and SiC at 2300-2700°C in argon and in vacuum has been established in special tests using specimens of 95% NbC + 5% SiC, 90% NbC + 10% SiC, 80% NbC + 20% SiC composites, the results revealing no interaction of the two materials whatsoever. Successful growing of SiC single crystals with NbC heaters and the longer service life of such heaters, as compared with graphite heaters, are favorable factors to be considered in production of SiC light-emitting diodes. References 4 (Russian).

2415/9835
CSO: 1842/172

EFFECTIVENESS OF VARIOUS HEAT TREATMENTS FOR HARDENING DEFORMED LOW-CARBON STEEL

Moscow METALLOVEDENIYE I TЕRMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 86 pp 38-39

[Article by G.N. Teplukhin, Northwestern Polytechnic Correspondence Institute]

[Abstract] A comparative evaluation of seven hardening heat treatments for deformed low-carbon steel, specifically MSt3sp steel (0.20% C, 0.22% Si, 0.63% Mn, 0.30% Cr, 0.30% Ni, 0.23% Cu, 0.10% P, 0.021% S), is made on the

basis of ultimate strength, 0.2% yield strength, percentage elongation and percentage reduction characterizing plasticity and toughness and percentage ductile fracture (measured at 20°C, -20°C, -40°C, -70°C) characterizing cold resistance. These heat treatments are: (1) hot rolling + air cooling; (2) normalizing at 900°C + air cooling; (3) isothermal holding at 450°C for 3 min + water cooling; (4) quenching in water from 900°C; (5) quenching in water from 900°C + tempering at 650°C for 30 min + water cooling; (6) forging + finish hot working at 340°C + water cooling; (7) forging + finish hot working at 840°C + water cooling + tempering at 650°C for 30 min + water cooling. Square bar specimens 150 mm long and 25x25 mm² in cross-section were heat treated in each mode, the specimens for heat treatments (6) and (7) having been forged from 150 mm long ones with 50x50 mm² cross-section into 600 mm long ones with 25x25 mm² cross-section. The data indicate that maximum strength is obtained by heat treatment (6), with attendant minimum plasticity. Cold resistance of hot-rolled steel is increased by normalizing (2) and more by isothermal heat treatment (3), but maximum cold resistance is obtained by quenching (4) or (5). An advantage of isothermal heat treatment is elimination of tempering.

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UDC 621.78:621.785.532:669.14

EFFECT OF PRELIMINARY HEAT TREATMENT ON PROPERTIES OF NITRIDED STRUCTURAL STEELS AND TOOL STEEL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian
No 3, Mar 86 pp 39-41

[Article by V.V. Simochkin, Bryansk Irrigation Machinery Plant]

[Abstract] An experimental study of structural steels 40Kh, US and tool steel 3Kh2V8 nitrided after various preliminary heat treatments was made, for the purpose of reconciling contradictory available data. One heat treatment was normalizing for 1 h. Another heat treatment was quenching + tempering. The third heat treatment was thermal cycling for 1 h: heating to slightly above the Ac_1 temperature + cooling to slightly below the Ar_1 temperature + cycling between these two temperatures four times + cooling from above the Ac_1 temperatures to room temperature + holding at that temperature before nitriding at 580°C (below the Ar_1 temperature) for 8 h. The core hardness of specimens after nitriding was measured with Brinell and Rockwell testers, the microhardness of the nitride layer was measured with a PIIT-3 tester. The thickness of the nitride layer was measured and its structure was examined under an NIM-7 microscope. Tension tests were performed in a UM-20 machine, notched-bar impact tests were performed with an MK-80A pendulum-ram. The data reveal that maximum ultimate strength and yield strength are obtained by preliminary quenching + tempering, maximum plasticity and toughness are obtained by preliminary thermal cycling, and that normalizing results in least improvement with increases of strength.

and percentage elongation respectively 25% and 40-50% smaller than the maximum attainable ones. The thickness of the nitride layer was found to be approximately the same after each preliminary heat treatment.

References 4 (Russian).

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UDC 669.71'782:621.762

GRAIN ORIENTATION AND PROPERTIES OF COLD-ROLLED POWDER-METAL STRIPS OF HIGH-SILICON AND HIGH-ALUMINUM IRON ALLOYS IN DISORDER-ORDER RANGE

Moscow METALLOVEDENIYE I TЕРМICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 86 pp 48-50

[Article by V.M. Beglov, A.M. Glezer, V.V. Dergach, N.M. Semenchinskij and Ye.F. Silnikova]

[Abstract] An experimental study was made in producing ductile tape of Fe + 5% Si, Fe + 6.2% Si, Fe + 16% Al powder alloys with retention of their high magnetic properties. Powder was produced by sputtering with nitrogen. Strips were produced by cold rolling and were cut with special scissors into 10 mm wide ribbons for mechanical testing by repetitive bending. Toroidal specimens were punched from strips or wound by tape for magnetic testing in a constant field and in a 50 Hz alternating field. All three alloys had been heat treated, the Fe-Si alloys by vacuum annealing at 1200°C and the Fe-Al alloy by vacuum annealing at 1200°C + furnace cooling + heating to 650°C and holding for 0.5 h + quenching in oil. Magnetostriiction was measured before and after heat treatment. The grain orientation in strips was determined with an x-radiograph. Despite a much lower nonmetallic impurity content but because of much stronger magnetostriiction, the Fe-Al powder-alloy tape was found to be magnetically inferior. All magnetic properties of cold-rolled 0.2 mm thick Fe + 6.2% Si powder-alloy tape were found to be as high as those of conventionally produced Fe + 6.2% Si tape. Ductility can be improved, with some sacrifice in magnetic properties, by using finer powder and by adding fine-disperse nonmetallic inclusions which, when uniformly distributed, stabilize the grain orientation. References 13: 4 Russian, 9 Western (2 in Russian translation).

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CSO: 1842/173

WELDING, BRAZING AND SOLDERING

UDC 621.791.16.03

FRICITION SPOT WELDING OF COPPER ALLOYS AND ALUMINUM ALLOYS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 1, Jan 86 pp 16-17

[Article by L.A. Polinovskiy, candidate of technical sciences, and Ye.S. Yanshin, engineer, Novosibirsk Institute of Railroad Transport Engineers]

[Abstract] A machine for friction spot welding of 0.5-2 mm thick sheets of low-carbon steels or nonferrous alloys was designed and built with provision for bilateral heating of the material, after a similar machine with unilateral heating had already been found to produce high-quality joints. The machine contains a welding fixture which holds the parts together between two disks, each on a spindle which also carries a piston, rotating driven by a 2 kW - 1500 rpm electric motor through V-belts and axially displaceable by a hydraulically driven spring mechanism. This machine was used experimentally for welding together 1+1.2+2 mm thick parts of M1 copper (15 pairs), 2+2 mm thick parts of AMn or V95 aluminum alloy each (10 pairs), 1.5+1.5 mm thick parts of AMg6 or D16T aluminum alloy each (7 pairs), as well as parts consisting of AMg6 aluminum alloy and M1 copper (12 pairs). Metallographic analysis of spot joints revealed identical microstructures of the seam metal and the base metal, just as in the case of joints produced by cold welding. The dependence of the shear strength of joints on the welding process parameters was evaluated on the basis of an orthogonal symmetric experiment according to a second-order plan, with heating time and beating pressure as the variable factors. Joints produced with the correct setting of all process parameters were found to have a shear strength 1.6-1.9 times higher than the minimum acceptable according to specifications for electric contact-resistance welding. References 2 (Russian).

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FRACTURE OF WELDED JOINTS OF CORROSION-RESISTANT STEEL IN CONTACT WITH COPPER

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 1, Jan 86 pp 24-25

[Article by V.Ye. Lazko, candidate of technical sciences, O.K. Revyakina, candidate of technical sciences, V.A. Kamanin, engineer, V.V. Cherepnin, engineer, and R.A. Alekseyeva, engineer]

[Abstract] Premature fracture of welded joints of corrosion-resistant austenitic steels (12Cr18Ni10Ti, 12Cr17Mg9AlN14) or transitional steels (07Cr18Ni16) in contact with copper, because of the resulting buildup of tensile stresses within the seam zone, is analyzed on the basis of the most characteristic situations. The principal factor in each case is presence of fine copper grains or films on the steel surface and their dissolution during the welding heat cycle. They may originate from the copper welding block or from the copper deposit on pins which have been used earlier for rolling the copper mounting plates. Other sources of copper are copper hammers used for corrective adjustment of the steel parts before welding and any other copper objects, whether tools or accessories, on the welding bench. References 9: 7 Russian, 2 Western (both in Russian translation).

2415/9835

CSO: 1842/176

UDC [621.791.755.052:669.231.5]:669.788:539.4

EFFECT OF HYDROGEN ON CRACKING RESISTANCE OF PLATINUM ALLOY

Kiev AVTOMATICHESKAYA SVARKA in Russian No 2, Feb 86

(manuscript received 1 Nov 84, in final version 1 Oct 85) pp 10-12, 29

[Article by O.D. Smiyan, candidate of technical sciences, B.I. Shnayder, candidate of technical sciences, D.M. Pogrebiskiy, candidate of technical sciences, L.A. Potapenko, engineer, and Ye.I. Butkova, engineer, Electric Welding Institute imeni Ye.O. Paton, UkrSSR Academy of Sciences]

[Abstract] Fracture of welded joints in glassmaking equipment made of platinum alloys has been found to be caused not only by contaminant particles penetrating from outside at high operating temperatures but also by some intrinsic factor affecting the behavior of the metal even under controlled conditions such as in microplasma welding. For the purpose of determining this factor, 0.5 mm thick disks of PtRhPdIrAu 20-10-0.1-0.1 alloy sheet were first annealed at 1000°C for 30 min and then welded together by the microplasma process with A-1255 and MPU-M machines. Concentric circular seams were produced at a rate of 2.5-3.5 mm/s with a current of

7-8 Å for the innermost seam and 12-13 Å for the four other successively larger ones. Welding was done under a gaseous shield of Ar + 4% H₂ and without it. After completion of each seam, the disk pair was air cooled for at least 5 min before being examined for cracks and tested for hardness. The mechanical data have been correlated with the results of mass-spectral analysis with an EKh0-4 scanning laser probe for determination of the hydrogen distribution. No significant differences were found between crack distributions and hydrogen distributions after welding under a gaseous shield or without it, but the hydrogen segregation within the thermal influence zones was found to become increasingly asymmetric toward the center. These findings indicate a high resistance of the PtRhP1IrAu 20-10-0.1-0.1 alloy to cracking during welding, this resistance nor the plasticity of the seam being diminished by an Ar + 4% H₂ shield. Locally under unfavorable conditions, however, the hydrogen concentration may become higher than elsewhere and weaken the welded joint. References 6 (Russian).

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UDC [621.791.72.021:669.3]:669.788

DEPENDENCE OF PORE FORMATION IN SEAM DURING ELECTRON-BEAM WELDING OF COPPER ON PRETREATMENT OF EDGES

Kiev AVTOMATICHESKAYA SVARKA in Russian No 2, Feb 86
(manuscript received 15 Aug 84, in final version 5 May 85) pp 21-25

[Article by O.K. Nazarenko, doctor of technical sciences, Electric Welding Institute imeni Ye.O. Paton, UKSSR Academy of Sciences, V.Ya. Agarkov, engineer, Scientific Research, Planning-Design and Technological Institute of Zhdanovtyazhmash Scientific-Production Association (Zhdanov Heavy Machinery Building), V.I. Ikonnikov, candidate of physico-mathematical sciences, and N.Kh. Solyanik, engineer, Odessa Institute of Maritime Fleet Engineers, Zhdanov branch]

[Abstract] Electron-beam welding of copper was studied for the purpose of determining the dependence of pore formation during cooling of the melt in the pool on the pretreatment of the edges and then accordingly optimizing that pretreatment. Experiments were performed on 12 mm thick plates of H1 copper (99.94% Cu, 0.0057% O₂, 0.003% Fe, 0.003% Zn, 0.002% Ag, 0.002% Pb, 0.002% Sn, 0.002% S, 0.002% P, 0.001% Bi, 0.001% Sb, 0.001% As, 0.00008% H₂) with U-250A equipment including a UL-119 electron gun. They were welded together in "lower position" with straight-through fusing at a rate of 25 m/h with a current of 360 mA under an accelerating voltage of 28 kV and under a pressure not exceeding 7·10⁻³ Pa. The edges prior to joining had been cleaned by scraping or shaving, without or with subsequent degreasing. Some edges were also intentionally separated by 0.5 mm copper spacers forming a gap or by intentionally built-up quasi-seams. The seam structure was examined and the porosity was measured by

x-radioscopy of cleavage surfaces with an RUP-50 transillumination instrument on RT-4M film. The mechanism of pore formation by hydrogen and water vapor bubbles generated during crystallization of molten copper and reaction with Cu₂ surface film was analyzed and verified with the aid of a special simulating apparatus and the new data, including the temperature profile along the pool edge. The results indicate that the porosity level in a seam, defined as total cross-sectional area of pores not smaller than 0.2 mm in diameter and thus not counting micropores, does indeed depend on the pretreatment of the edges. An additional experimentally tried pretreatment of the edges, namely with a 1.2 k^W low-power electron beam scanning the edge at a frequency of 50 Hz while the plate is moved under it at a velocity of 15 m/h, was found to result in adequately solid seam with hardly any pores forming along the solidification front.

References 17: 15 Russian, 1 Polish, 1 Western.

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CSO: 1842/175

UDC 621.791.754'291.952:669.715:620.178.3

LOW-CYCLE FATIGUE OF WELDED JOINTS OF 1201 ALUMINUM ALLOY

Kiev AVTOMATICHESKAYA SVARKA in Russian No 2, Feb 86
(manuscript received 29 Jan 85, in final version 16 May 85) pp 39-41, 45

[Article by V.I. Ryazantsev, candidate of technical sciences, Yu.I. Tolkachev, engineer, G.A. Slavin, doctor of technical sciences, and A.S. Roshchina, engineer, Moscow]

[Abstract] Welded joints of 1201 aluminum alloy were tested for low-cycle fatigue resistance and its dependence on technological factors such as misalignment of the edges, form of the material, and postwelding corrective seam treatment. Specimens for welding included 3,4,5,6 mm thick sheets, 30 mm thick hot-rolled plates, 80 mm thick wrought plates, and molded strips. They were quenched and artificially aged prior to welding, in one pass or in several passes depending on the thickness, with a tungsten d.c. electrode and a Sv-1201 welding wire under a helium shield in a special welding machine. From 1000x300 mm² large welded pairs were cut and milled 220x40 mm² large test specimens with 20 mm gage width. These were loaded in NGP machines at frequencies of 5-8 cycles/min with a 0.1 cycle asymmetry factor, after having been inspected by x-ray for continuity. The results of life tests on a 40,000 cycles base and analysis of defects simulated by grooves cut along the seam indicate that shifting of the edges reduces the life of welding joints most significantly, a 10% shift reducing it by a factor of 1.4-2.0 and a 35% shift reducing it by a factor of 10 or more. They also indicate that 1201 sheet and wrought plate have the highest fatigue resistance, much higher than that of 1201 molded strip. Ultrasonic post-treatment of weld seams was found to shorten the life of joints when done

with sharp needles but not to affect it when done with a spherically rounded pin. Manual hammering of seams was found to statistically scatter the fatigue indicators, but mechanized hammering on a block with a groove was found to lengthen the life of joints appreciably by a factor of 1.7-3.5 with eventual fracture occurring within the seam. Fracture of all otherwise post-treated joints and those not post-treated did occur within the fusion zone.

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HEAT TREATMENT OF CUTTING TOOL HARD-FACED WITH 110Mo6Cr3V2Ti POWDER WIRE

Kiev AVTOMATICHESKAYA SVARKA in Russian No 2, Feb 86
(manuscript received 3 Dec 84, in final version 21 Oct 85) pp 46-51

[Article by B.N. Gorpenyuk, engineer, V.A. Stepanenko, candidate of technical sciences, V.G. Permyakov, doctor of technical sciences, V.V. Khilchevskiy, doctor of technical sciences, and M.N. Gapchenko, doctor of technical sciences, Kiev Polytechnic Institute]

[Abstract] In the search for adequate materials for high-speed metal cutting tools without tungsten, the PP-RI-1 (110Mo6Cr3V2Ti) molybdenum powder alloy steel in wire form has been developed at the Kiev Polytechnic Institute for hard-facing tool bits made of cast steel otherwise not acceptable because of excessive grain growth and liquation with carbide precipitation. This new material contains neither tungsten nor cobalt, but the peculiarities of layerwise hard-facing, characterized by fast directional crystallization within a small volume, call for special stringent intermediate and final heat treatment taking into account the faster grain growth in molybdenum steel than in tungsten steel. For the purpose of optimizing the heat treatment, a study of tool steel hard-faced with this wire containing 1.10-1.47% C was made which included structural examination and hardness measurement. The wire was welded on inside a copper chill mold with water cooling, which produced a material with 54-58 Rockwell C hardness. Dynamic tests were performed on specimens with V-notches, using a pendulum with a maximum strike energy of 49 J. Metallographic examination under a scanning electron microscope and an optical microscope, as well as fractographic examination under a scanning electron microscope with the stage at a 30° angle, were done after chemical and then electrolytic etching of the surface of the microsection. This was followed by mechanical abrasion of the surface with Fe_2O_3 powder before chemical deep etching. X-ray structural analysis was performed with a URS-50IM diffractograph and a scintillation counter. Heat treatment included annealing at temperatures covering the 700-900°C range, different than the conventional range for rolled or wrought alloy

steels, with subsequent continuous cooling at 10, 25, 75°C/h and then quenching from 1000-1300°C. The results indicate that the optimum annealing temperature for this new molybdenum powder steel lies within 800-840°C for minimum hardness, 24-32 Rockwell C when the carbon content is lowest (1.1% C), with subsequent coolant at 25°C/h. Quenching from 1300°C for optimum cutting performance is permissible, austenite grain growth being inhibited by a carbide grid, but requires subsequent tempering at a temperature not lower than 580°C for attainment of 65 Rockwell C hardness with complete transformation of austenite. References 8 (Russian).

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CSO: 1842/175

UDC 621.791.762.002:[669.14+669.71]

CHARACTERISTICS OF TRANSITION ZONE IN ALUMINUM-STEEL JOINTS PRODUCED BY CONTACT BUTT WELDING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 2, Feb 86
(manuscript received 7 Feb 85) pp 57-60

[Article by M.A. Lukin, engineer, Pskov Heavy Electric Welding Equipment Plant, corresponding member UkrSSR Academy of Sciences, S.I. Suchuk-Yatsenko, doctor of technical sciences, V.R. Ryabov, doctor of technical sciences, A.N. Muraveynik, engineer, and I.Ya. Dzykovich, candidate of technical sciences, Electric Welding Institute imeni Ye.O. Paton, UkrSSR Academy of Sciences]

[Abstract] A new continuous-fusion electric contact-resistance butt welding machine has been developed at the Electric Welding Institute and is manufactured at the Pskov plant, for joining stacks of aluminum sheets up to 12,000 mm² in cross-section across the edges as sheaths to steel bars up to 26,000 mm² in cross-section. For an optimization of this welding process on such a K-607 machine, stacks of 1 mm thick and 150x70 mm² large sheets of AD1 aluminum were welded to bars of St3 steel 115x230 mm² in cross-section. The operation was performed under 16 different sets of conditions, with successively varied upsetting pressure (14-60 MPa), upsetting allowance (4-20 mm), and flashing allowance (17-63 mm), but with upsetting allowance (4-20 mm), and flashing allowance (17-63 mm), but with upsetting speed (350 mm/s) and flashing speed (0.8-6 mm/s) as well as no-load voltage (12.7 V) and overhang beyond the electrodes after upsetting (12 mm) held constant over the entire range of each variable parameter. A study of the transition zone in each case was made including metallographic and structural examination under an MIM-8 microscope, microhardness measurement with a PMT-3 tester, and x-ray microchemical analysis with a "Cameca" instrument which yielded the distribution of aluminum and the steel elements. According to the results, optimum joints were produced under an upsetting pressure of 60 MPa, with a 9 mm upsetting allowance and a 43 mm flashing allowance. With an upsetting allowance smaller than 7 mm pores and cracks

in the weld seam. With an upsetting allowance larger than 13 mm the outermost sheets of the aluminum stack got sheared during upsetting so that the mechanical characteristics of the joint deteriorated. With a flashing allowance smaller than 17 mm or larger than 50 mm the mechanical characteristics of the joint were degraded by buildup of an interlayer of intermetallic compounds. Therefore, an upsetting allowance of 9-11 mm and a flashing allowance of 40-50 mm are recommended. References 7: 5 Russian, 2 Western.

2415/9835
CSO: 1842/175

EXTRACTIVE METALLURGY AND MINING

ECONOMIC DEVELOPMENT OF BAM AREA

Moscow EKONOMICHESKAYA GAZETA in Russian No 3, Jan 86 p 7

Article by N. Singur, chief of a Gosplan USSR section and Candidate of Economic Sciences: "Problems of Udkan: Prospects for the Development of a Mining Industrial Complex"

Text In the draft of the Basic Directions of the Economic and Social Development of the USSR the goal has been set of putting BAM/Baykal-Amur Railroad into constant operation along its entire length and starting the widespread economic assimilation of the zone of this railroad. Major importance is also being assigned to the Udkan Industrial Center.

In the Kodaro-Udkan mining region, geologists have exposed and explored large deposits of copper, iron, coal, rare metals, non-metallic raw materials, building materials, and ground waters. The Udkan copper sandstone deposit is situated on the outskirts of the Charskaya basin close to the BAM line and the Chineyskoye copper ore deposit, which is of great economic interest, is nearby.

The Charskoye magnetic quartz rock deposit has been discovered 20-30 kilometers from the BAM line. Large reserves, a simple ore concentration technology, a high-quality magnetite concentrate suitable for the direct reduction of iron, the possibility of stripping a significant part of the ore reserves by open-cut mining, closeness to the BAM route--all of these things determine the high industrial value of the deposit.

The assimilation of the unique Kagutinskoye rare metal deposit, located 70 kilometers from the BAM route, promises to have a great effect. This deposit's ores also contain cryolite--a valuable raw material for the aluminum industry.

The Sakunskoye synnyrite(potassium-aluminum rocks) deposit is inferior in scale to the Synnyrskoye deposit in the Northern Baykal area, but it also has an advantage--it is situated in immediate proximity to the BAM line and to the Udkan copper deposit which will significantly facilitate its development.

The Apsatskoye coaking coal deposit, located 35 kilometers to the north of the BAM line, is very promising. The geological reserves are estimated at one and a half billion tons of which no less than 300 million tons are suitable for extraction by open-cut mining. The deposit can become a large raw material base of the by-product coke industry and provide the future Udkan GOK/mining and concentration combine as well as the industrial enterprises, cities and settlements of the BAM area with high-quality power coals.

Deposits of various building materials which are of great help in opening up the territory are found on the land of the Kedaro-Udokan mining area.

Even a short review of the mineral and raw material potential testifies to the unique combination in a relatively small space of large reserves of various types of mineral resources which creates a realistic basis for the formation in the future in the northern part of the Chita Oblast of a large territorial mining and industrial complex for the extraction and treatment of mineral raw material.

The Udokan industrial center, based on the copper sandstone deposit, is the most important unit in this complex. It has already been handed over by the geologists to the USSR Mintsvetmet [Ministry of Nonferrous Metallurgy] for industrial development.

As a whole, the Udokan copper province is unique in its vastness and in the size of its reserves. Only a part of it has been explored as yet. Geologists have to continue the work in the 12th Five-Year Plan.

Unfortunately, USSR Mintsvetmet is conducting scientific research and planning and surveying work for the construction of the Udokan GOK with a considerable lag from the established deadlines. USSR Mintsvetmet must speed up the development of a general plan for the placement and development of the Udokan Mining and Concentration Combine which must be backed at and approved by USSR Gosplan [State Planning Committee] and USSR Gosstroy [State Committee for Construction]. This, to a large extent, will determine the paths for assimilating the unique deposit and will permit the development of a total program of research engineering-geological, surveying, and construction and installation work.

Scientific research is being carried out of late on developing technological processes for the extraction and treatment of Udokan deposit ores. A decision was made on the design and construction in the 12th Five-Year Plan at the site of the future GOK of an experimental industrial complex consisting of a mine and concentration plant for developing effective methods for the extraction and concentration of all types of Udokan ores.

During the development of the plan, in particular, the use of strip pit rocks and concentration "tails" in the construction industry, along with the use of already-developed deposits of building materials, ought to be provided for.

The use of hydroelectric power, e.g., the Mokskaya GES [hydroelectric power plant] on the Vitim River, is, in our opinion, advisable for the power supply of the complex based on ecological requirements. Its construction will help to regulate the flow of the river and to use the most fertile tidal marsh soils in the Muyskaya basin in order to provide the agricultural production of the entire western section of the BAM area, to also include the Udokan industrial center.

The creation of an experimental industrial complex in the area of the future GOK and its functioning urgently require breaking a motor vehicle road from the BAM route to the deposit and, subsequent to this, also a railroad siding in this direction.

Special concentration equipment and mining machinery are required for opening up the Udkan deposit. Both the already manufactured domestic 180-ton dump trucks, 140-ton dump cars, and 20-cubic excavators and the new equipment recently developed by the Mining Institute of the Siberian Department of the USSR Academy of Sciences must be tested at the experimental industrial complex under the extreme conditions of the North and high mountains.

The selection of a method for opening up the deposit is one of the most complex and fundamental problems: whether to create in these really difficult natural and climatic conditions a city at Udkan with an entire social infrastructure for 60,000-100,000 people or to use the duty-shift method, locating people in more favorable climatic conditions at a distance of up to 200 kilometers from Udkan?

At the present time both options have a good many supporters. I would hope that in the discussion of this problem and especially when making a final decision, the arithmetical approach connected with saving resources on the construction of a city would not predominate.

At the meeting of the party economic aktiv which took place on 6 September at Tyumen, it was noted in the speech of M. S. Gorbachev that each construction plan for new projects in Siberia and the Far East must be thoroughly based, from the social point of view, on providing for the improvement in the conditions of labor and life of the people. It is necessary to apply the same standard to the solution of the complex ecological problems connected with opening up the large deposit under unique natural conditions which must be preserved for future generations. Here there are also the cleanest lakes with valuable species of fish, and health springs, and rare animals.

All of the problems in forming the Udkan complex and its first section--the industrial center, cannot be fully examined in the engineering plan. In our opinion, the question must be one of a special-purpose comprehensive program of forming the Udkan mining industrial complex. Its development should attract planning and scientific research organizations of various types. The yearly and five-year plans for the economic and social development of the BAM area, developed in USSR Gosplan with the participation of local planning organs, will be the instrument for its realization.

8524
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SHEMONAIKHA COMPLEX ORE DEPOSIT NOW OPERATIONAL

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 30 Jan 86 p 1

Article by V. Burenko, correspondent in Ust-Kamenogorsk: "Deposit in Operation"

Text The new Shemonaikha complex ore deposit was turned over for industrial operation almost one year earlier than the projected time period. The raw material mined here is characterized by an increased metal content. There are few harmful impurities in it. A LEP/electric power transmission line/ has been extended over the mountains to the new pit at a rapid pace and an access road has been constructed. Forty-ton BelAZ's/vehicles manufactured by the Belorussian Motor Vehicle Plant/ are working at the strip pit and 110-ton dump trucks and powerful bulldozers will arrive here in the near future. The Eastern Kazakhstan Copper Chemical Combine has now been provided with excellent ore up to the end of the millennium.

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LEAD CONCENTRATE UNIT DELAYED

Tashkent PRAVDA VOSTOKA in Russian 11 Apr 86 p 3

[Article by V. Vakhayev, correspondent of ALMALYKSKIY RABOCHIY: "They Are Not Hurrying"]

[Text] At the lead concentration mill of the Almalyk Mining-Metallurgical Combine imeni V.I. Lenin, they are preparing to launch an industrial unit which will make possible a considerable improvement in the quality of the lead concentrate. It is the first industrial process introduced here that was developed by scientists of the Evening Mining and Metallurgical Department of the Almalyk branch of the Tashkent Polytechnical Institute imeni Beruni. It is a question of copper, the content of which in the lead concentrate should be reduced to a minimum in the process of concentrating ore.

Until recently, the problem of drawing copper from the lead concentrate hardly existed for the Almalyk concentrators. Alarms started, however: the copper in the concentrate increased! The flotation plant workers were obliged to jig the ore, but in the residues, along with copper went lead and a number of associated metals, and the quality of the concentrate suffered.

The Almalyk Mining and Metallurgical Department of the Tashkent Polytechnic Institute proposed that the Almalyk Mining-Metallurgical Combine develop an industrial process which would make it possible not only to separate copper out of the lead concentrate without damage to the other components, but also to prepare for metallurgical production. The combine took on the wages of the scientists. They concluded an economic agreement in 1981.

In a year, A. Chaplygina and V. Chazov, senior lecturers and candidates in Technical Sciences, submitted a variant of the industrial process which was later patented. The materials used in this development were accessible to the combine. The process of separating out the copper passing through at high temperatures--up to 90 degrees--was not set up by the purchaser.

So, at the beginning of this year, the scientists' work was finished--the necessary industrial process exists. Due to it the concentrators could not only reduce the copper content in the lead concentrate to 0.1-0.3 percent, but could also achieve a considerably higher content in the separated product of copper itself. In other words, the lead mill could become the supplier of

high-quality concentrate not only for lead, but also for copper alloy production. At the same time, precious metals were being saved. The scientists estimated that even with a content of one percent copper in the lead concentrate, the new industrial process would make it possible to "squeeze out" of it 95,000 rubles of profit a year!

The workers of the Institute of Geology and Geophysics of the Uzbek SSR Academy of Sciences, exploring in the region of the Altyntopkanskoye Lead deposit, confirmed the urgency of the new development. They reported that the copper content in the lead ore will increase.

The development of the scientists of the Almalyk branch of the Tashkent Polytechnic Institute is a step along the path to collaboration with the production workers. So far, however, it has not been introduced. After all, though, now introducing the scientific idea into production most rapidly depends only on the Almalyk Mining-Metallurgical Combine.

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DISTRIBUTION OF Au AND As AMONG PRODUCTS OF SMELTING OF ROBUST Au-As CONCENTRATES

Moscow TSVETNYYE METALLY in Russian No 3, Mar 86 pp 36-37

[Article by V.N. Mashuryan, A.G. Borisova and N.A. Strukova]

[Abstract] Robust Au-As concentrates were smelted with slag into ferrous matte for de-arsenization, at 1300°C for 2.5 h in an inert atmosphere. Alundum crucibles with the specimens were, for this purpose, placed in a KO-14 electric furnace with automatic temperature control. Reduction of oxides was facilitated by addition of coke in amounts of 1.5-5.0% and the acidity of the slag was varied by additions of lime or sandstone. The results indicate that, in order to produce a matte with high Au content and low As content, it is necessary either to roast the concentrate down to a 0.1-0.6% As content in the scoria and then smelt it into a matte high in gold using a slag with an acidity index of 0.6-0.8, or to smelt the concentrate without prior roasting but using a slag with an acidity index of 2.8-3.2 and then scavenge the matte, which contains less than 1.0% As, so as to further enhance the Au concentration in it. The acidity index of slag is defined as the ratio

$$K = \frac{SiO_2 + Al_2O_3}{FeO + CaO + MgO}.$$
 References 4 (Russian).

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EFFICIENCY OF EXTRACTION OF FINE GOLD BY GRAVITY PROCESS EQUIPMENT

Moscow TSVETNYYE METALLY in Russian No 3, Mar 86 pp 94-95

[Article by T.B. Belova and S.I. Khramchenko]

[Abstract] Extraction of fine gold by gravity process equipment was evaluated on the basis of two samples from two plants now extracting it by not very effective flotation and cyanidation. Sample ZIF-1 with 33.4 rel.% Au contained quartz, argillaceous mica, carbonates, iron oxides, and not more than 2.0% sulfides. In this sample nonhomogeneous crusts containing 30-45 rel.% Ag had grown onto over 30% of all gold grains, in various shapes. Sample ZIF-2 with 66.7 rel.% Au contained garnet, epidote, pyroxene, chlorite, magnesite, less than 5.0% quartz and less than 0.5% sulfides. The gravity process was monitored through a helical separator 500 mm in diameter, a helical sluice 900 mm in diameter, a sludge concentrator bench, a jigger, and a Mosley vanner. The results indicate the feasibility of efficient extraction of free fine gold by the gravity process, orbital oscillations such as in the Mosley vanner contributing to the highest yield.

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USE OF REAGENT IM-50 IN FLOTATION OF Cu-Ni ORE

Moscow TSVETNYYE METALLY in Russian No 3, Mar 86 pp 96-98

[Article by L.D. Artemyeva, R.I. Sulina, V.A. Shenderovich, V.I. Ryaboy and N.E. Shchukina]

[Abstract] Use of the reagent IM-50, alkyl hydroxamine acids of the C₇-C₉ fraction, for enrichment of Cu-Ni sulfide ores containing pyrrhotite with iron cations as well as pentlandite and chalcopyrite was studied for improvement of the nickel extraction. It was necessary to combine this reagent with the two conventionally used sulfhydryls, namely butyl xanthogenate as strong collector and butyl aerofloat as weak collector. The expediency of this technique has been confirmed on samples of cuprous Cu-Ni ore containing principally those three minerals. The experiment was followed through the complete process of comminution to 80% of the 74 μ m fraction - flotation for 10 min - second comminution to 95% of the 44 μ m fraction - repurification - third comminution to 95% of the 30 μ m fraction - flotation of intermediate product for 10 min - second repurification, which yielded a joint concentrate separate from the lumped tailings from two pilot flotations. Using the reagent IM-50 without the sulfhydryls proved not

to be technologically effective, because of its selective sticking much more to minerals with high Fe^{+++} content on the surface and much less to minerals containing Cu and Ni. The optimum ratio of reagents was found to lie within the IM-50:xanthogenate:aerofloat = 1:2-6.5:7.5-8.5 range. The total amount does not need to be larger than the total amount of the two sulfydryls now used alone, since the reagent IM-50 replaces them proportionately.
References 13: 9 Russian, 4 Western.

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